# BusWorks® 900EN Series – Modbus TCP/IP 10/100MB Industrial Ethernet I/O Modules

## Model 963EN-4012 12 Channel DC Current Input
## Model 964EN-4012 12 Channel DC Voltage Input

# USER'S MANUAL

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**8500-718-D04J008**

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Symbols on equipment:

Means "Refer to User's Manual (this manual) for additional information".

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**IMPORTANT SAFETY CONSIDERATIONS**

You must consider the possible negative effects of power, wiring, component, sensor, or software failure in the design of any type of control or monitoring system. This is very important where property loss or human life is involved. It is important that you perform satisfactory overall system design and it is agreed between you and Acromag, that this is your responsibility.

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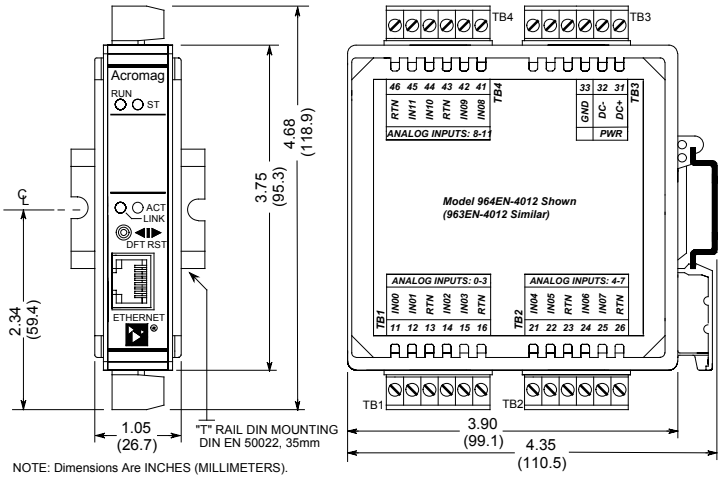
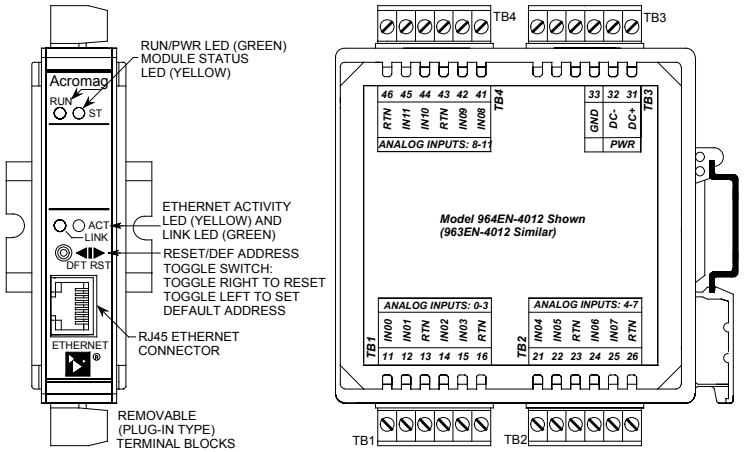
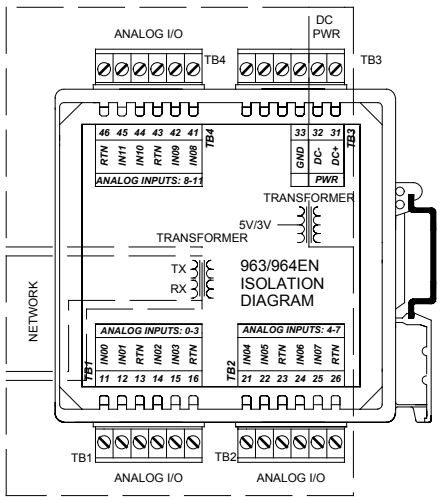



NOTE: Dimensions Are INCHES (MILLIMETERS).

MODEL 963/964EN ENCLOSURE DIMENSIONS




*The toggle switch is used to toggle the module into or out of Default Mode (toggle left), or to reset the module (toggle right). In Default Communication Mode, the yellow ST LED blinks slowly and the module assumes a fixed static IP address of "128.1.1.100", a default subnet mask of "255.255.255.0", a default username of "User", and a default password of "password00".*




## MOUNTING AND DIMENSIONS

*Unit mounts to "T" type DIN rails (35mm, type EN50022).*

*Units may be mounted side-by-side on 1-inch centers.*

***WARNING:** IEC Safety Standards may require that this device be mounted within an approved metal enclosure or sub-system, particularly for applications with exposure to voltages greater than or equal to 75VDC or 50VAC.*

## CONTROLS & INDICATORS

*Green Run LED is ON if power is on and will blink in "wink" ID mode.*

*Yellow ST LED blinks ON/OFF if module is in default communication mode and stays ON if one or more inputs are over/under-range.*

*Green LINK LED ON if auto-negotiation has successfully established a connection.*

*Blinking Yellow ACT LED signals PHY network Activity (busy).*

## ISOLATION BARRIERS

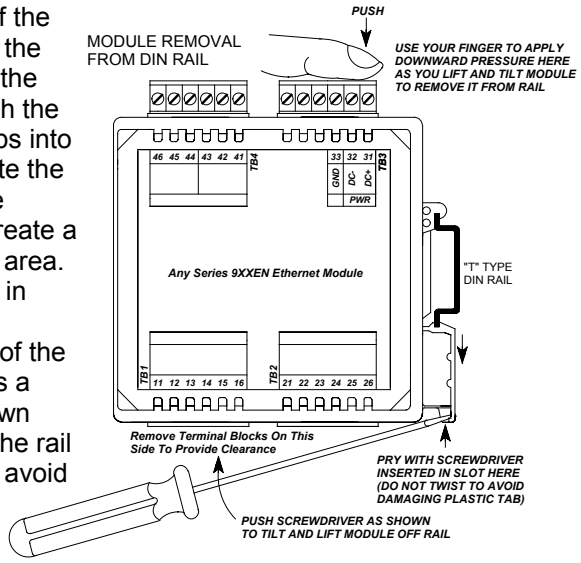
*Dashed Lines denote isolation barriers.*

*The input circuit, network, and power circuit are isolated from each other for safety and noise immunity.*

# CONNECTIONS

## DIN-Rail Mounting & Removal

When attaching the module to the T-type DIN rail, angle the top of the unit towards the rail and locate the top groove of the adapter over the upper lip of the rail. Firmly push the unit towards the rail until it snaps into place. To remove, first separate the input terminal block(s) from the bottom side of the module to create a clearance to the DIN mounting area. Next, while holding the module in place from above, insert a screwdriver into the lower arm of the DIN rail connector and use it as a lever to force the connector down until the unit disengages from the rail (do not twist the screwdriver to avoid damaging plastic).


PUSH
MODULE REMOVAL FROM DIN RAIL
USE YOUR FINGER TO APPLY DOWNWARD PRESSURE HERE AS YOU LIFT AND TILT MODULE TO REMOVE IT FROM RAIL
Any Series 9XXEN Ethernet Module
"T" TYPE DIN RAIL
Remove Terminal Blocks On This Side To Provide Clearance
PRY WITH SCREWDRIVER INSERTED IN SLOT HERE (DO NOT TWIST TO AVOID DAMAGING PLASTIC TAB)
PUSH SCREWDRIVER AS SHOWN TO TILT AND LIFT MODULE OFF RAIL

## Network

*For 100Base-TX systems, use data grade Unshielded Twisted-Pair (UTP) wiring that has a 100Ω characteristic impedance and meets the EIA/TIA Category Five wire specifications.*

*It is recommended that you use a crossover CAT-5/5E cable to connect this device to your PC.*

*For 10Base-T systems, you may use Category 3, Category 4, or Category 5/5E UTP/STP cable.*

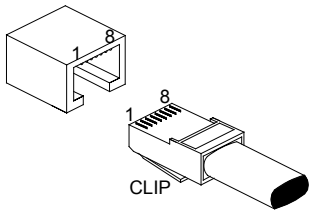
*In either case, you are limited to 100 meters between any two devices.*

RJ45 MDI AND MDI-X CONNECTIONS

| PIN | MDI WIRING | MDI-X WIRING |
|---|---|---|
| 1 | Transmit + | Receive + |
| 2 | Transmit - | Receive - |
| 3 | Receive + | Transmit + |
| 4 | Not Used | Not Used |
| 5 | Not Used | Not Used |
| 6 | Receive - | Transmit - |
| 7 | Not Used | Not Used |
| 8 | Not Used | Not Used |

Note Crossover Connections

ETHERNET PORT




RJ-45 CONNECTOR

MINIMUM RECOMMENDED CABLE

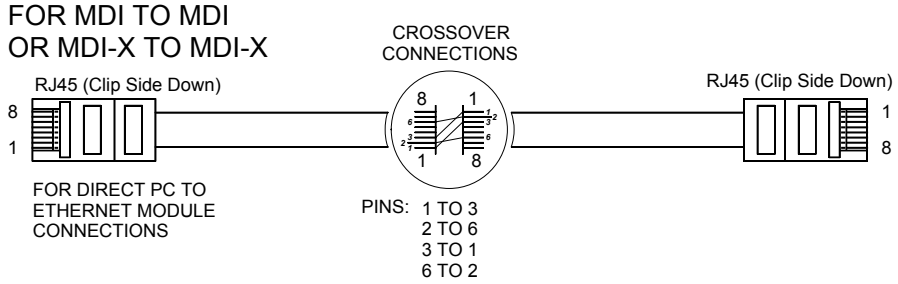
| SPEED | DISTANCE | CABLE |
|---|---|---|
| 10Base-T | 100M | CAT 3, CAT 4, or CAT 5 UTP/STP |
| 100Base-T | 100M | CAT 5 UTP/STP |

The Ethernet port of this module is wired MDI and does not include automatic crossover. The Ethernet port of your PC is also wired MDI and may not include automatic crossover. As such, you must use a crossover cable like that shown below when connecting this device directly to a PC.

*A crossover cable simply connects the differential transmit pair on each end, to the receive pair on the opposite end.*

*Use a standard (direct) cable when connecting to a hub or switch port, which are generally wired MDI-X.*

CROSSOVER CABLE FOR MDI TO MDI OR MDI-X TO MDI



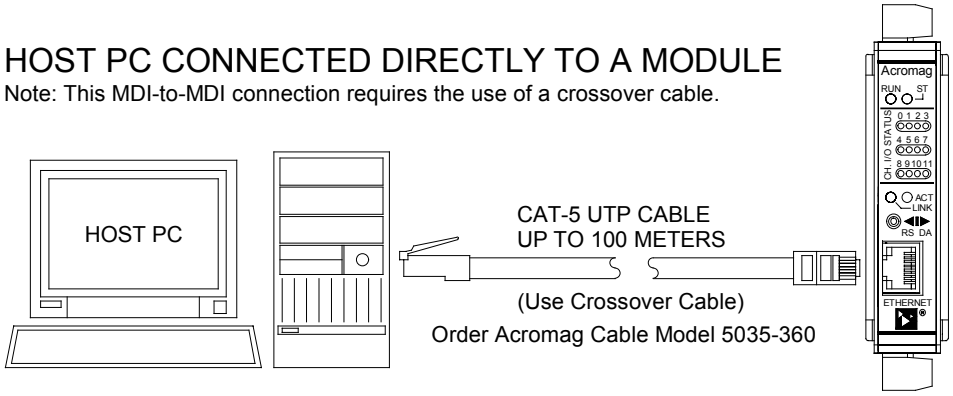
Refer to the Accessory Cables section at the back of this manual for more information on accessory cables, including patch and crossover cables available from Acromag and other vendors.

# CONNECTIONS

## Network

### HOST PC CONNECTED DIRECTLY TO A MODULE

Note: This MDI-to-MDI connection requires the use of a crossover cable.



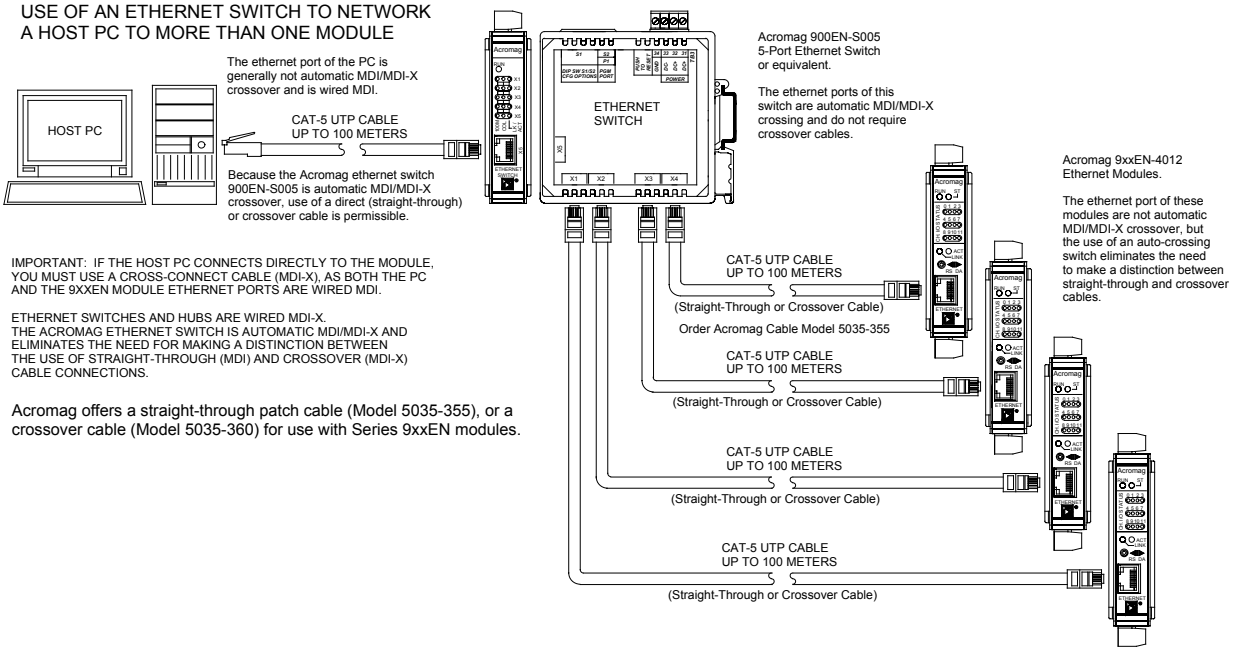

Acromag 983EN-4012 Ethernet Module.

The ethernet port of this module is not automatic MDI/MDI-X crossover and is wired MDI.

**TIP:** You can significantly enhance the EMI/RFI performance of your network connections by using Category 5E STP cable (Shielded Twisted Pair) with shielded RJ45 plug connectors. This will also help to protect your installation from damage due to ESD (Electro-Static Discharge). The use of shielded cable is strongly recommended for installations in harsh industrial environments and/or in the presence of strong electrical fields.

You can use an Ethernet switch or switching hub to build a network of Ethernet modules, similar to that shown below. This drawing shows how to network-connect Acromag Series 9xxEN modules to a 5-port Ethernet switch (Acromag Model 900EN-S005). Note that the 900EN-S005 switch includes automatic MDI/MDI-X crossover and a straight-through or crossover cable(s) may be used to connect to the modules and the PC.

### USE OF AN ETHERNET SWITCH TO NETWORK A HOST PC TO MORE THAN ONE MODULE


HOST PC
The ethernet port of the PC is generally not automatic MDI/MDI-X crossover and is wired MDI.
CAT-5 UTP CABLE
UP TO 100 METERS
Because the Acromag ethernet switch 900EN-S005 is automatic MDI/MDI-X crossover, use of a direct (straight-through) or crossover cable is permissible.
ETHERNET SWITCH
Acromag 900EN-S005
5-Port Ethernet Switch
or equivalent.
The ethernet ports of this switch are automatic MDI/MDI-X crossing and do not require crossover cables.
CAT-5 UTP CABLE
UP TO 100 METERS
(Straight-Through or Crossover Cable)
Order Acromag Cable Model 5035-355
CAT-5 UTP CABLE
UP TO 100 METERS
(Straight-Through or Crossover Cable)
CAT-5 UTP CABLE
UP TO 100 METERS
(Straight-Through or Crossover Cable)
CAT-5 UTP CABLE
UP TO 100 METERS
(Straight-Through or Crossover Cable)
Acromag 9xxEN-4012 Ethernet Modules.
The ethernet port of these modules are not automatic MDI/MDI-X crossover, but the use of an auto-crossing switch eliminates the need to make a distinction between straight-through and crossover cables.

IMPORTANT: IF THE HOST PC CONNECTS DIRECTLY TO THE MODULE, YOU MUST USE A CROSS-CONNECT CABLE (MDI-X), AS BOTH THE PC AND THE 9XXEN MODULE ETHERNET PORTS ARE WIRED MDI.

ETHERNET SWITCHES AND HUBS ARE WIRED MDI-X. THE ACROMAG ETHERNET SWITCH IS AUTOMATIC MDI/MDI-X AND ELIMINATES THE NEED FOR MAKING A DISTINCTION BETWEEN THE USE OF STRAIGHT-THROUGH (MDI) AND CROSSOVER (MDI-X) CABLE CONNECTIONS.

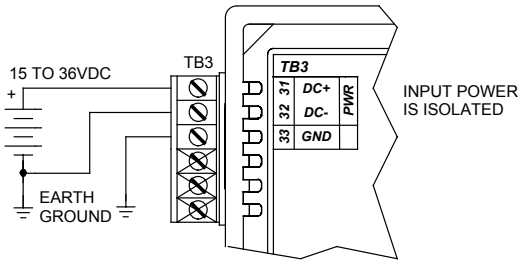
Acromag offers a straight-through patch cable (Model 5035-355), or a crossover cable (Model 5035-360) for use with Series 9xxEN modules.

# CONNECTIONS

## Power

| Voltage | Current |
|---|---|
| 15VDC | 113mA |
| 18VDC | 96mA |
| 24VDC | 74mA |
| 36VDC | 54mA |

✓ Connect 15-36V DC to the power terminals labeled DC+ & DC-. Observe proper polarity. For supply connections, use No. 14 AWG wires rated for at least 75°C. **CAUTION:** Do not exceed 36VDC peak.




**CAUTION: Risk of Electric Shock** – More than one disconnect switch may be required to de-energize equipment before servicing.

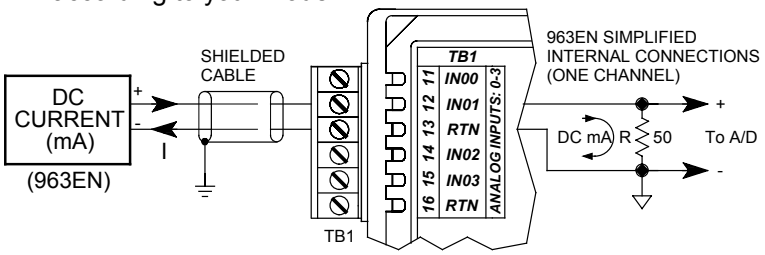
**IMPORTANT – External Fuse:** If unit is powered from a supply capable of delivering more than 1A to the unit, it is recommended that this current be limited via a high surge tolerant fuse rated for a maximum current of 1A or less (for example, see Bel Fuse MJS1).

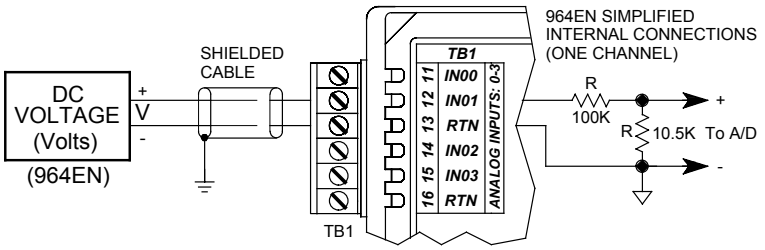
## Analog Inputs

✓ Connect analog input signals to the input terminals as shown below according to your model.

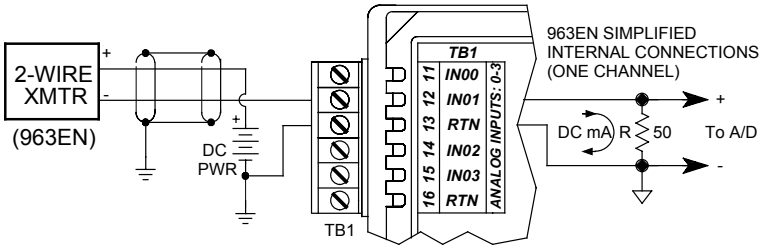
*Input is DC current (963EN), or DC voltage (964EN).*

*Inputs share common (RTN) and are not isolated channel-to-channel.*

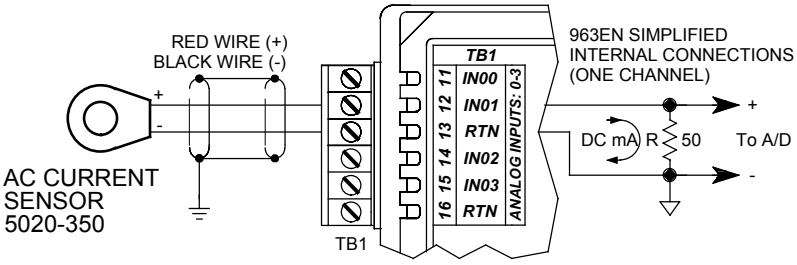



*Connection To A 2-Wire Transmitter (963EN Only)*




*Connection To Acromag AC Current Sensor 5020-350.*



✓ Connect Earth Ground as shown in the connection drawings above. Additionally, connect the GND terminal (TB3-33) to earth ground.

The ground connections noted are recommended for best results. If sensors are already grounded, use caution and avoid making additional ground connections which could create ground loops.

**The plastic module housing does not require earth ground.**

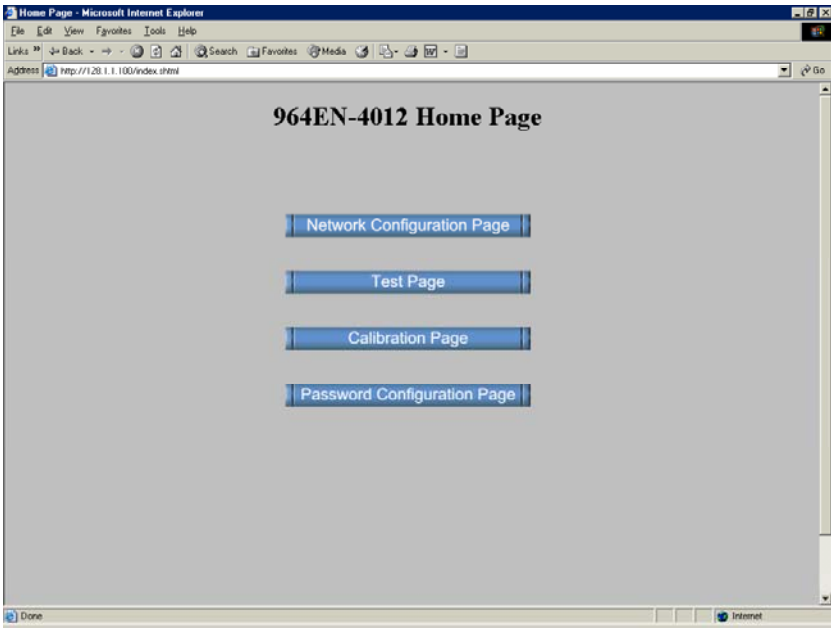
## Earth Ground

***Warning:*** *To comply with safety and performance standards, use shielded cable and connect earth ground as noted. Failure to use good wiring and grounding practices may be unsafe and hurt performance.*

# WEB BROWSER

## Home Page

This module supports Modbus over TCP/IP. You may use your own software to issue Modbus command to this module (see Modbus Registers), or you may use a standard web browser to achieve basic functionality. The 963/964EN-4012 modules have built-in web pages that allow you to setup, control, and calibrate the module via a web browser. Simply execute your web browser, type the IP address assigned to your module in the "Address" window (http://128.1.1.100/ for our example), click [Go], and you will be presented with a Home Page window similar to that shown below:

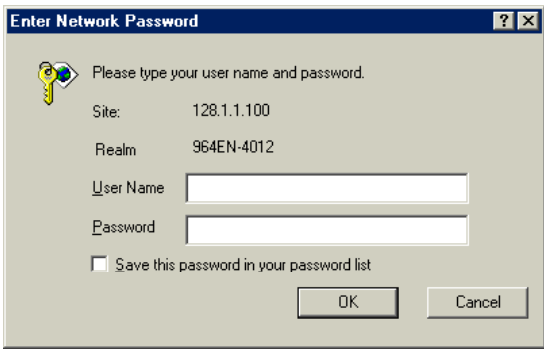



The Home Page provides buttons to access the other web pages of this module that are used to configure the network parameters, change the user name and password, calibrate the module, and operate/test the module.

For each new browser session that accesses the Home Page of this module, you will be presented with a window prompting you to enter the current User Name and Password as shown below. This information is required before the program will allow you to make any other selections. **The default user name and password is "User" and "password00" respectively.** After entering these defaults, you may wish to invoke the Password Configuration Page to change these parameters to something more meaningful to you.

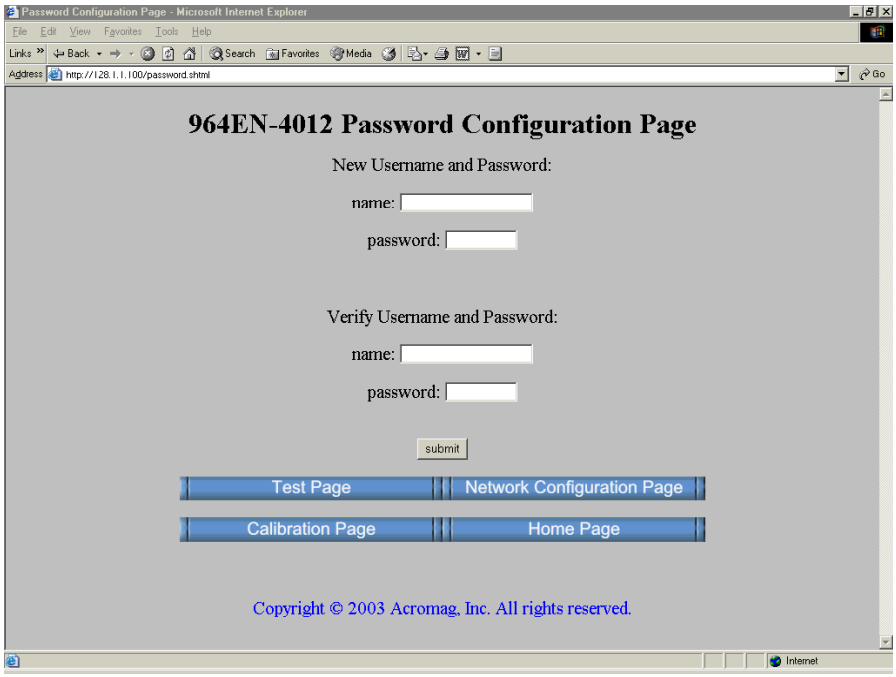
# WEB BROWSER

## Home Page




**IMPORTANT:** If you forget your user name and password, you can always toggle the module into default mode via the default mode toggle switch at the front of the module, and the password and username will revert to the original defaults noted above, thus allowing you to re-invoke the Password Configuration Page and change the username and password as required.

## Password Configuration Page




Use up to 20 alphanumeric characters (case sensitive) to specify your username, and 10 alphanumeric characters (case sensitive) to specify a password. You will have to type in these entries twice to help prevent errors.

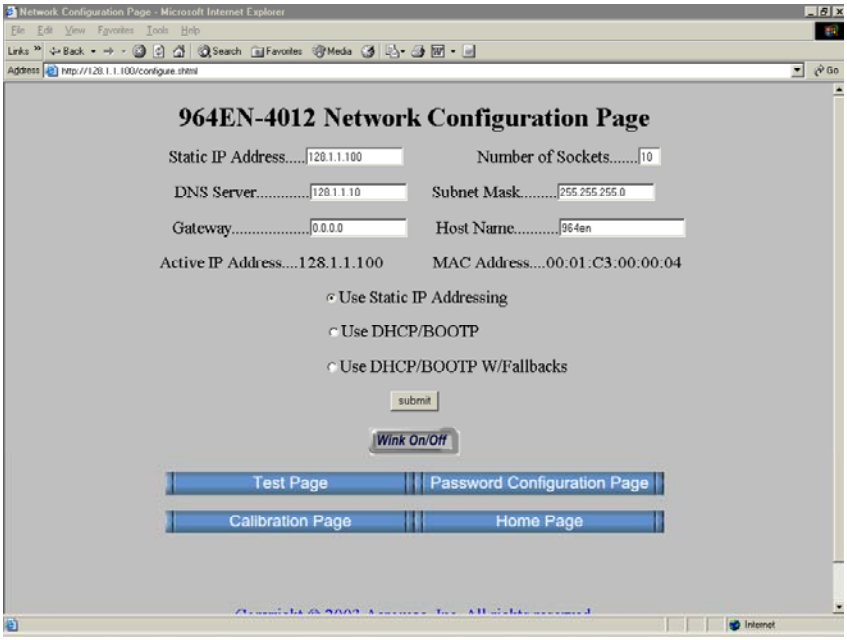
Click the **submit** button to write your changes to the module.

After completing your username/password changes, click on the appropriate button at the bottom of the page to select another web page. If you made changes, you may be prompted to re-enter your new username and password before being permitted to move to other pages.

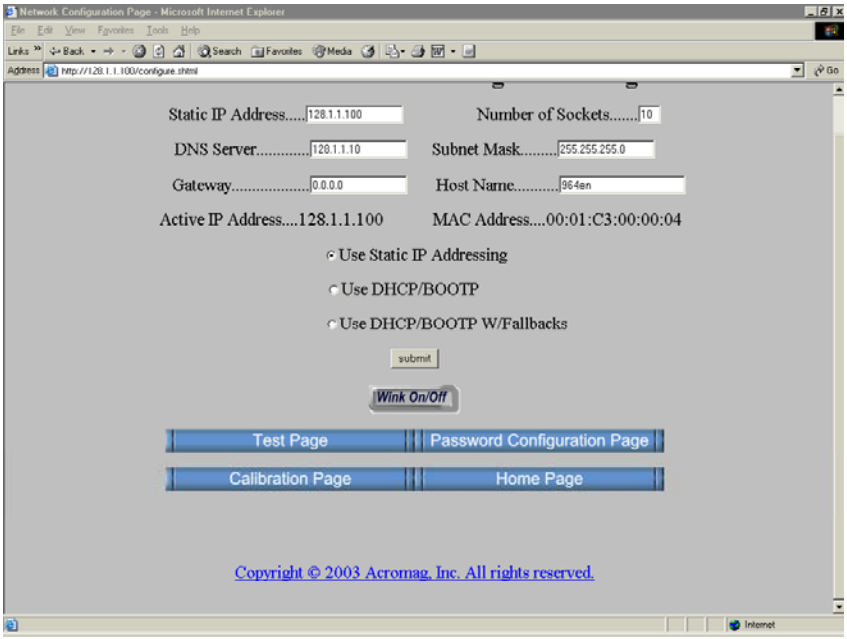
## WEB BROWSER
### Network Configuration

After setting your username and password, you can click the "Network Configuration Page" button to set the network configuration parameters for the module. You may have to consult your network administrator to complete the contents of this page.

*Note that Acromag series 9xxEN Ethernet I/O modules may take from 3 to 30 seconds to boot upon power-up, depending on your network configuration and whether a DHCP server is present.*




Use the scroll bar on the right to scroll down the page as shown below:




An **IP Address** is a unique identification number for any host (this module) on any TCP/IP network (including the internet). The IP address is made up of four octets (8 bits), each octet having a value between 0-255 (00H-FFH). It is expressed here in decimal form, with a period placed between octets.

# WEB BROWSER

## Network Configuration

*This module can be placed into a default communication mode via the DFT toggle switch at the front of the module.*

*Default Mode uses a static IP address of "128.1.1.100", a default subnet mask of "255.255.255.0", a default username "User", and a default password "password00".*

A **Static IP Address** is as the name implies—*static*, and represents a unique fixed IP Address that is generally assigned by your service provider or system administrator. The default mode static IP address assigned to this module is 128.1.1.100 (refer to product side label).

**NOTE:** In order to network your PC with an Acromag module, you may have to consult with your network administrator and either temporarily change your TCP/IP configuration (see TCP/IP Properties of Network Configuration in Windows), or create a separate private network using a second network adapter installed in your PC (recommended). The necessary steps will vary with your operating system. Refer to Acromag Application Note 8500-734 to help accomplish this (located on the CDROM shipped with your module or via download from our web site at www.acromag.com).

The **Number of Sockets** refers to the number (1-10) of Modbus TCP/IP access points to allow for this host. The default allows up to 10 sockets, but you can restrict access by reducing this number. Internally, the module uses port number 502 which is reserved for Modbus.

The **DNS Server** refers to the IP address of the Domain Name Server used on this network. A DNS server relates symbolic names to actual IP addresses, while the DHCP server is responsible for dynamically passing out IP addresses.

A **Subnet Mask** is used to subdivide the host portion of the IP address into two or more subnets. The subnet mask will flag the bits of the IP address that belong to the network address, and the remaining bits correspond to the host portion of the address. The unique subnet to which an IP address refers to is recovered by performing a bitwise AND operation between the IP address and the mask itself, with the result being the sub-network address.

**Gateway** refers to the IP Address of the gateway, if your local area network happens to be isolated by a gateway. If a gateway is not present, then this field should contain an unused address within the host subnet address range. Typically, it is assigned the first host address in the subnet.

The **Host Name** is the name to be assigned to this host if its address happens to be assigned dynamically using DHCP.

The **Active IP Address** refers to the current IP Address being used by this host, as opposed to any new assignments being made via this page.

The **MAC Address** refers to the Media Access Control Address that uniquely identifies the hardware of this device. This is a unique fixed address assigned to this module at the factory. In IEEE 802 networks, the Data Link Control (DLC) layer of the OSI Reference Model is divided into two sublayers: the Logical Link Control (LLC) layer, and the Media Access Control (MAC) layer. The MAC layer interfaces directly with the network media (each different type of network media requires a different MAC layer).

By default, the module is setup to use **Static IP Addressing and a Static IP Address of 128.1.1.100**. You can optionally choose to have the IP address assigned dynamically via DHCP/BOOTP or DHCP/BOOTP w/Fallbacks. This will also require that you specify a valid Host Name. Note that DHCP/BOOTP w/Fallback will revert to the static IP address if your DHCP or BOOTP server cannot be found at the address specified.

# WEB BROWSER

## Network Configuration

In general, BOOTP (Bootstrap Protocol) refers to an internet protocol that enables a diskless workstation to discover its own IP address, the address of a BOOTP server on the network, and a file to be loaded into memory to boot the machine. This enables the workstation or device server to boot without requiring a hard or floppy disk drive. BOOTP works similar to DHCP, but is usually found in older systems. This protocol is defined by RFC 951.

DHCP (Dynamic Host Configuration Protocol) refers to a protocol for assigning dynamic IP addresses to devices on a network. With dynamic addressing, a device can have a different IP address every time it connects to the network. In some systems, it can even change while it is still connected. DHCP also supports a combination of static and dynamic IP addresses. DHCP/BOOTP with fallback will revert to static IP addressing if the DHCP or BOOTP server cannot be found.

The unit includes a default address toggle switch to cause the module to assume a preset default factory address. This switch is at the front of the module and is used to toggle the module into, or out of Default Mode. If you use the toggle switch at the front of the module to place the module in default mode, then "Default Communications Mode" will be indicated at the bottom of this screen.

*The Default Communication Mode uses a static IP address of "128.1.1.100", a default subnet mask of "255.255.255.0", a default username of "User", and a default password of "password00".*

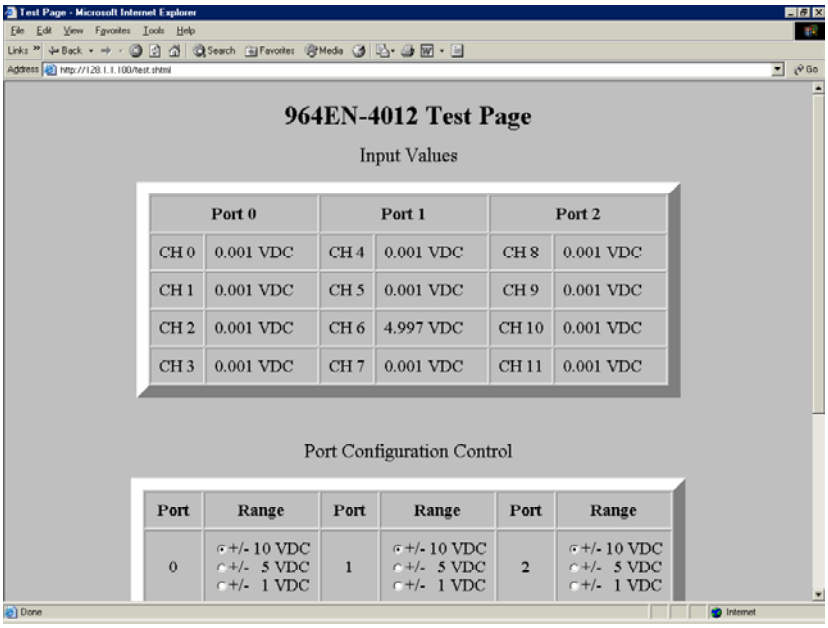
Click the **Submit** button to complete any changes made on this page.

Click the **Wink On/Off** button to toggle the module in/out of "wink" ID mode. In this mode, the module's green RUN LED will blink to confirm identification.

Refer to the Technical Reference section of this manual to learn more about IP Addressing terms and concepts.

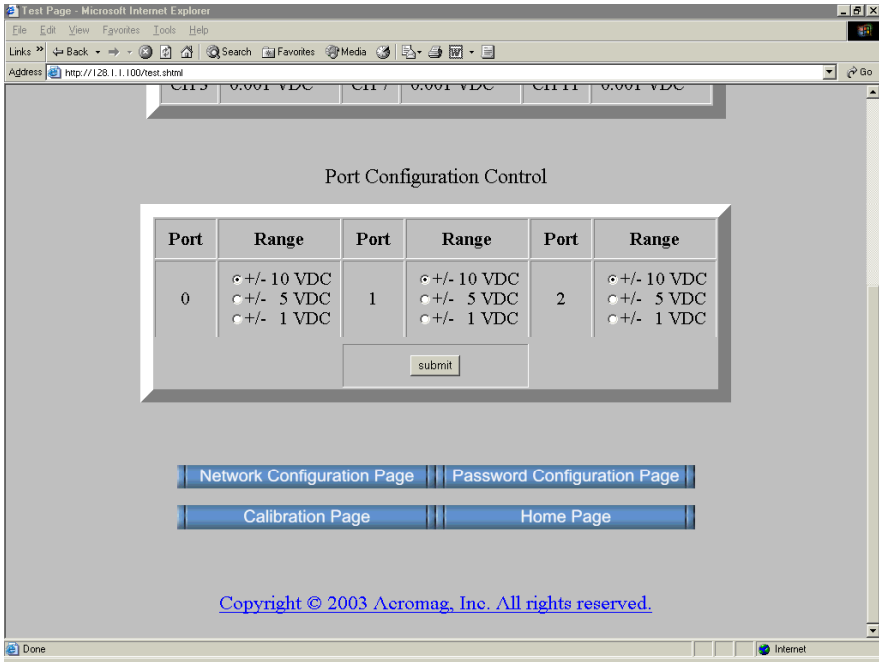
## Test Page

After completing your username and password assignment, plus your network configuration parameters, you can use the Test Page to operate your module. The Test Page will allow you to read inputs and change input ranges on this model.



## WEB BROWSER
### Test Page

Use the scroll bar on the right to scroll down the page as shown below:




***TIP:*** *Viewing a module's web page is treated similar to viewing a web page on the internet. The first time you open a page, its image is stored as a temporary internet file in PC memory. However, each subsequent attempt to view that page will need to automatically update that image, especially when making configuration changes. With Internet Explorer, click the "Internet Options" of the "Tools" menu, select the "General" tab, locate the "Temporary Internet Files" information and click on the "Settings" button. Then select "Automatically" under "Check for newer versions of stored pages:". Then click [OK] to return to the "General" screen, and click [OK] again to save your settings.*

Note that the 12 channels of this module are divided into 3 groups (ports) of 4 channels each. Each port represents one pluggable I/O terminal block (6 screws). Port Number 0 refers to channels 0-3, port number 1 refers to channels 4-7, and port number 3 to channels 8-11. Input signals for each channel are indicated to 3 decimal places as shown.

**IMPORTANT:** The input level indicated only reflects the level of the inputs at the moment this screen is invoked and this does not continuously update. You can click your browser's refresh button to get a new input update.

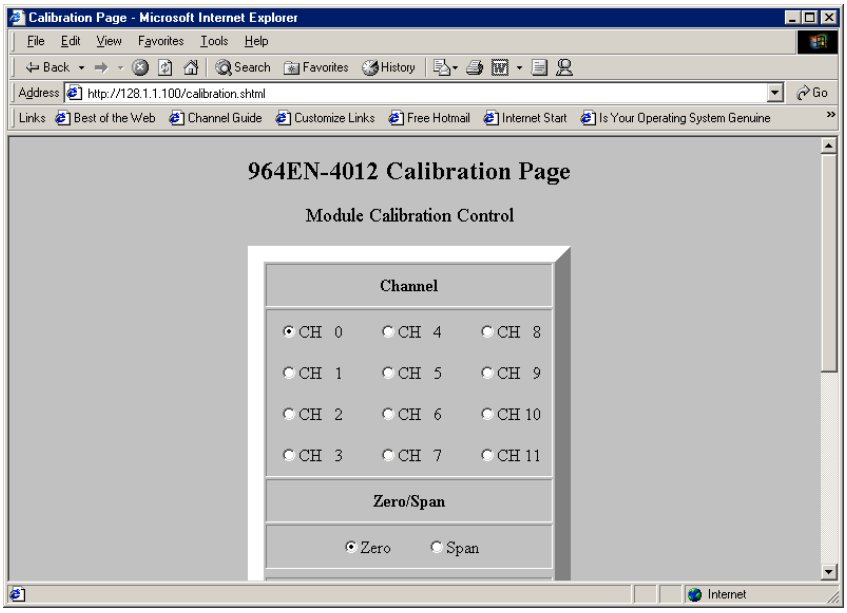
You can also use the Port Configuration Control of this page to change the input range for the channels on a port-by-port basis. For the 964EN shown, you may select from bipolar voltage ranges ±1V, ±5V, or ±10V. For the 963EN, you could choose 0-20mA, 4-20mA, 0-11.17mA, or 0-1mA. Note that the 0-11.17mA range is intended to be used with an optional AC current sensor (Acromag Model 5020-350) which will output 0-11.17mADC for various 50-60Hz AC current ranges.

Note that your range selection will apply to all channels of the entire port (group of four channels). Click on "submit" to execute your range change.

## WEB BROWSER

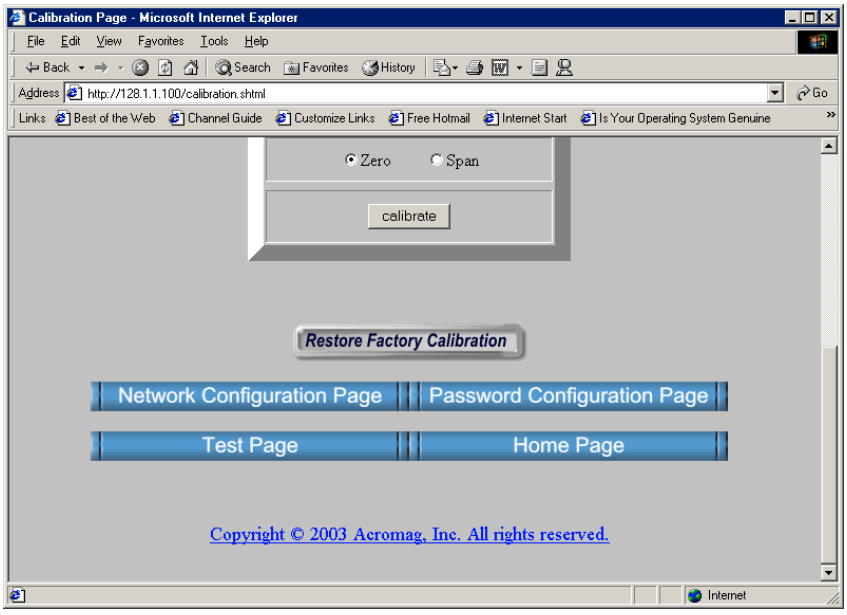
### Calibration Page

The Calibration Page will allow you to recalibrate each channel's zero and span signal as required. Simply select the channel to be calibrated, choose zero or span (zero first), apply the zero or full-scale signal to the input, then click calibrate. For best results, always calibrate zero before span.


Calibration Page - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites History
Address http://128.1.1.100/calibration.shtml
Go
Links Best of the Web Channel Guide Customize Links Free Hotmail Internet Start Is Your Operating System Genuine
964EN-4012 Calibration Page
Module Calibration Control
Channel
CH 0 CH 4 CH 8
CH 1 CH 5 CH 9
CH 2 CH 6 CH 10
CH 3 CH 7 CH 11
Zero/Span
Zero Span
Internet

***IMPORTANT:*** *This module has already been calibrated at the factory and recalibration is not normally required, except as necessary to correct for long term component aging, or to satisfy your company's maintenance requirements. Do not attempt to recalibrate this module unless absolutely required, as miscalibration will negatively affect the module's performance.*

Use the scroll bar on the right to scroll down the page as shown below:


Calibration Page - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites History
Address http://128.1.1.100/calibration.shtml
Go
Links Best of the Web Channel Guide Customize Links Free Hotmail Internet Start Is Your Operating System Genuine
Zero Span
calibrate
Restore Factory Calibration
Network Configuration Page
Password Configuration Page
Test Page
Home Page
Copyright © 2003 Acromag, Inc. All rights reserved.
Internet

***Note:*** *You may click the Restore Factory Calibration button to return all module channels to their original factory calibration if calibration has been compromised (all channels are restored together).*

The following table gives the calibration values for these models. These represent the input signals required to calibrate the range endpoints. Your success in recalibrating the input will depend upon the accuracy and precision of your signal source.

# WEB BROWSER

## Calibration Page

***Note (963EN):*** *The 4-20mA range is calibrated when the 0-20mA range is calibrated and is not calibrated separately. All other ranges are calibrated separately.*

If recalibration of any input is required, all applicable ranges of both models should be done. On the 963EN-4012, the 4-20mA input range is a sub-range of the 0-20mA range and is automatically calibrated at the same time.

| INPUT RANGE | ZERO Cal (Cal Lo) | FS Cal (Cal Hi) |
|---|---|---|
| 963EN-4012 (12 Current Inputs) | | |
| 0 to 20mA & 4 to 20mA | 1.0mA | 20.0mA |
| 0 to 11.17mA | 1.0mA | 11.17mA |
| 0 to 1mA | 0.25mA | 1.00mA |
| 964EN-4012 (12 Voltage Inputs) | | |
| -10V to +10V DC | -10.0V | +10.0V |
| -5V to +5V DC | -5.0V | +5.0V |
| -1V to +1V DC | -1.0V | +1.0V |

**IMPORTANT:** For best results, be sure to use a precision signal source capable of reproducing the nominal endpoint signals at least as accurate as the module itself (better than ±0.1% of span). Always allow the module to warm up a few minutes prior to calibration.

*You can choose to use the web browser calibration page to accomplish calibration (easiest), or via direct register access as described below.*

**Method 1 – Calibration Using The Built-In Browser Interface:**

1. Make sure that the range that needs calibrating is currently selected.
2. Bring up the browser interface and select the calibration page.
3. Apply either the zero or span input signal to the channel to be calibrated. Calibrate the zero endpoint signal first, before the span endpoint signal.
4. Wait about 10 seconds for the input to settle and be read.
5. Click on the channel number and select either zero or span calibration.
6. Click the "Calibrate" button. The page will first refresh & then calibration may continue. Repeat this process for the other endpoint (span).
7. Repeat steps 2-5 for the other input channels to be calibrated.

**Method 2 - Calibration Via The Modbus TCP/IP Interface:**

1. Write to the appropriate Port Input Range Register to select the input range to be calibrated for your channel of interest.
2. Write 24106 (5E2AH) into the Calibration Access Register to remove write protection from the calibration registers.
3. Apply the zero calibration signal (Cal Lo, see table) to the input to be calibrated and allow the input to settle about 10 seconds.
4. Write a 16-bit value to the Zero Calibration Register with a set bit in the bit position that corresponds to the channel number to be calibrated (one channel at a time). If you were calibrating the zero of channel 5, you would write 0x0010 to the Zero Calibration Register. The module will replace calibration coefficients immediately, no reset needed.
5. Apply the full-scale calibration signal (Cal Hi, see table) to the input to be calibrated and allow the input to settle about 10 seconds.
6. Write a 16-bit value to the Span Calibration Register with a set bit in the bit position that corresponds to the channel number of the channel to be calibrated (one channel at a time). For example, if you wanted to calibrate the span of channel 0, write 0x0001 to the "Span Cal Register".
7. Write to the Port Input Range Register to select the next range to be calibrated for this channel. Repeat steps 3-6 for the next range as required.
8. Repeat steps 3-7 for the other channels as required.
9. When finished calibrating, write 0x0000 to the Calibration Access Register (Holding register 21) to replace write protection to the calibration registers and prevent miscalibration.

Upon power-up, the green "Run" LED will turn ON. A continuous blinking Run LED indicates "wink" ID mode. If the Run LED remains OFF and correct power has been applied, then either the internal power supply has failed or a fatal error has occurred.

# TROUBLE-SHOOTING

## Diagnostics Table

| SYMPTOM | POSSIBLE CAUSE | POSSIBLE FIX |
|---|---|---|
| *Green RUN LED does not light.* | Internal +3.3V power has failed. | Return module for repair. |
| *Continuous flashing green RUN LED.* | Module in "wink" mode. | Read Module Status register to verify "wink" status. Write 5555H to Wink Mode Toggle Register to toggle wink mode off/on. |
| *Cannot communicate.* | Power ON at the module? | Check power. Is green RUN LED ON? |
| | Connecting cable is not a crossover cable.<br>***TIP:*** *To check cable, hold both ends in same position and read the wire colors through the clear portion of the plug from left to right. If colors are arranged in the same order, you have a straight cable.* | This module's ethernet port is wired MDI. You must use a crossover cable when connecting this module to your PC or another device also wired MDI. If you are connecting to an Ethernet switch or hub, then a direct cable is used.<br>**Note:** If your Link LED is ON, you have connected using the correct type of cable, but it could still be defective. |
| | Wrong IP Address | Change the IP address of the module or the PC so that both match. Try the default module address of 128.1.1.100. |
| *Many Communication Errors.* | Is cable segment longer than 100M? | Maximum distance between two nodes is limited to 100 meters using approved cable. |
| | Correct Cable? | Shielded CAT-5/5E cable or equivalent is recommended. |
| | Missing earth ground connection. | Connect earth ground to TB3-33 GND terminal adjacent to power terminal. |
| *Cannot Browse Module.* | Your browser may be setup to use a proxy server for LAN communications. | Temporarily disable the use of a proxy server by your browser (see procedure of next page). |

*If your problem still exists after checking your wiring and reviewing this information, or if other evidence points to another problem with the unit, an effective and convenient fault diagnosis method is to exchange the module with a known good unit. Acromag's Application Engineers can provide further technical assistance if required. Complete repair services are also available from Acromag.*

# TROUBLE-SHOOTING

## Trouble Browsing Your Module?

Please refer Acromag Application Note 8500-734 for help in setting up network communication with your module (located on the CDROM shipped with your module or via download from our web site at www.acromag.com). This document gives details for changing your PC's TCP/IP configuration in order to communicate with your module (see TCP/IP Properties of Network Configuration in Windows).

If you have carefully followed this procedure and you still cannot browse your module, you may have the web browser of your laptop or PC setup to use a proxy server when browsing the web. If you are using Internet Explorer, Refer to the "Tools" pulldown menu, select "Internet options…", click the "Connections" tab, then click the "LAN Settings" button. Locate the Proxy server information and uncheck the box next to the statement "Use a proxy server for your LAN". Then click [OK] to return to the "Connections" screen, and click [OK] again to save your settings.

You should now be able to use Internet Explorer to browse the module as required. However, to later restore your PC's connection to your company network, you may have to re-enable the use of a proxy server for your LAN.

## Getting Out Of Trouble

There is no built-in error detection to prevent you from writing invalid values to a configuration register. As such, if you inadvertently write an invalid value to an internal register, you could cause the module to become inoperable under certain conditions. If this happens, in order to regain control of the module, the module can either be re-downloaded at the factory, or you can try restoring the module to its initial configuration by following this procedure:

*So, your module's "gone wild", follow this procedure to restore it to its initial configuration and regain control.*

**Procedure For Restoring any 9xxEN Module to its Initial Configuration**

1. While module power is OFF, press and hold the front-panel toggle switch in the default (DFT left) position.
2. While continuing to hold the toggle switch in the default position, apply power to the module.
3. After a few seconds, the Status LED will begin to blink quickly and you can release the default switch at this point. The module will continue to boot itself as it normally does. That is, the green RUN LED will blink for 1-10 seconds as the unit acquires its address, then remain ON for normal operation.
4. If the STATUS LED fails to blink rapidly after a few seconds and the RUN LED just blinks for a few moments as it normally does, then reinitializing the module has failed and you should try it again. This time, make sure that the DFT switch is completely depressed and held while powering the unit. Also make sure that you are pressing the DFT toggle in the DFT direction (left), rather than the RST direction (right).

# TECHNICAL REFERENCE

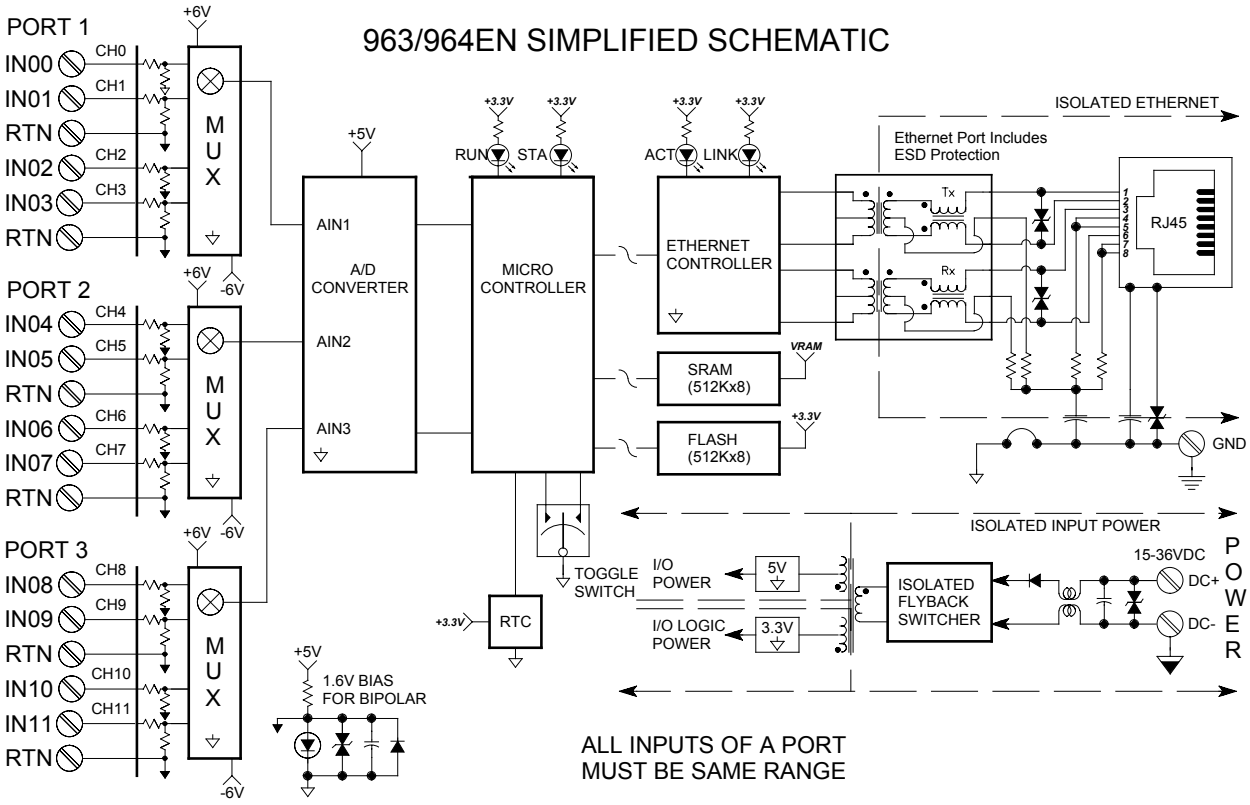
## KEY FEATURES

- **Safety Agency Approvals** – CE, UL, & cUL listed, plus Class 1; Division 2; Groups A, B, C, D approval.
- **Fully Isolated** – Input channels (as a group), network, and power are all isolated from each other for safety and increased noise immunity.
- **Modbus TCP/IP Protocol Support –** Supports up to 10 sockets/ masters (maximum number is user-selectable) using port number 502 (standard Modbus TCP/IP default).
- **Built-In Web Pages -** Allows unit to optionally be configured, controlled, calibrated, and monitored via access with a standard web browser over ethernet.
- **Convenient "Wink" ID Mode Support** – Blinks green RUN LED in wink mode as a tool to help identify specific remote units.
- **Fully Independent w/ Direct I/O Connection** – Self-contained with no special bus couplers, power supply, or mount rack required to operate.
- **Network Port is Transient Protected** – Shielded RJ45 port includes transient protection from ESD, EFT, and other transients.
- **10Base-T and 100Base-TX Support** – Per IEEE 802.3/802.3u.
- **Auto-Negotiated 10/100Mbps, Half or Full Duplex.**
- **Flexible Multi-Range Analog Inputs –** Select either DC current or DC voltage input signals according to your model.
- **Port-to-Port Range Variability** – Each terminal port (group of 4 channels) can have different ranges configured, but channels of the same port must share the same range.
- **Optional AC Current Input (963EN Only) –** An optional AC current sensor can be purchased separately to support AC current inputs.
- **Precise High-Resolution A/D Conversion** – Modules use high-resolution, low noise, sigma-delta, analog-to-digital conversion for high accuracy and reliability.
- **Plug-In Terminal Blocks & DIN-Rail Mount -** Make mounting, removal, and replacement easy.
- **Nonvolatile Reprogrammable Memory** – Allows the functionality of this device to be reliably reprogrammed thousands of times.
- **Operation/Diagnostic LED Indicators Aide Troubleshooting** – Yellow ACT LED indicates port activity (busy). Green LNK LED indicates link (auto-negotiation complete and connection established). Green RUN LED indicates power or blinks in wink ID mode. Yellow ST LED indicates default communication mode (blinks) and input over/under-range (constant ON).
- **Built In Hardware Watchdog** - A hardware watchdog timer is built into the microcontroller that causes it to initiate a self reset if the controller ever "locks up" or fails to return from an operation in a timely manner.
- **Wide-Range DC-Power** – Wide range diode-coupled for use with redundant supplies, and/or battery back-up.
- **Hardened For Harsh Environments** - For protection from RFI, EMI, ESD, EFT, & surges. Has low radiated emissions per CE requirements.
- **Wide Ambient Operation** – Reliable over a wide temperature range.

## HOW IT WORKS

These input modules will interface with up to twelve analog input channels of DC current or DC voltage according to the model number, and provide an isolated 10/100 Ethernet interface for configuration, monitoring, and control of the input module. The 963EN will also condition AC current input signals when used with an optional AC current sensor (Acromag Model 5020-350). Input channels are arranged in three groups (ports) of four inputs, which are driven to separate channels of the A/D converter. Because each port feeds a different A/D channel, each channel of the port must have the same input range. However, different ports may use different input ranges. Current inputs sink into a precision 50Ω resistor (963EN). Voltage inputs feed precision 10:1 resistive dividers (964EN). A multiplexer is used to connect the voltage from each channel of a port to a channel of the A/D converter (one A/D channel per port). The A/D converter then applies gain to the signal, converts the analog signal to digital, and then digitally filters the signal. The digitized signal is then transmitted serially to the microcontroller. The microcontroller completes the transfer function according to the input type and range per its embedded program. Configuration and calibration parameters are stored in non-volatile memory integrated within the microcontroller. The I/O terminals and the Ethernet port terminals also include transient suppression. A dedicated Ethernet controller handles Ethernet communication. A wide input switching regulator (isolated flyback) provides isolated power to the I/O circuits and the Ethernet controller. Refer to the simplified schematic shown below to help gain a better understanding of the circuit.

963/964EN SIMPLIFIED SCHEMATIC



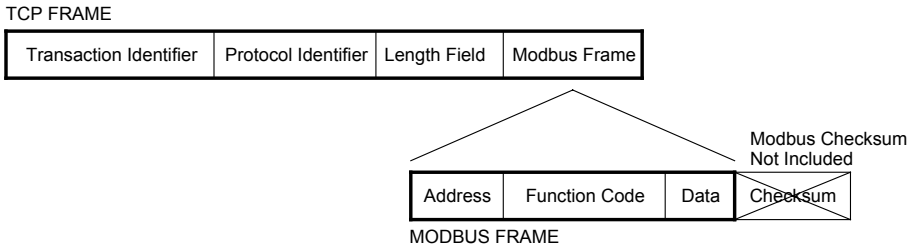
## ABOUT MODBUS TCP/IP

TCP/IP refers to Transmission Control Protocol and Internet Protocol. TCP/IP allows blocks of binary data to be exchanged between computers. TCP/IP is everywhere and is the foundation for the World Wide Web. The primary function of TCP is to ensure that all packets of data are received correctly. IP makes sure that messages are correctly addressed and routed. Note that the TCP/IP combination does not define what the data means or how the data is to be interpreted, it is merely a *transport protocol*.

Modbus is an *application protocol*. It defines rules for organizing and interpreting data and is essentially a messaging structure that is independent of the underlying physical layer. It is freely available and accessible to anyone, easy to understand, and widely supported by many manufacturers.

Modbus TCP/IP uses TCP/IP and Ethernet to carry the data of the Modbus message structure between devices. That is, Modbus TCP/IP combines a physical network (Ethernet), with a networking standard (TCP/IP), and a standard method of representing data (Modbus). In effect, a Modbus TCP/IP message is simply a Modbus communication encapsulated in an Ethernet TCP/IP wrapper.

In practice, Modbus TCP embeds a Modbus data frame into a TCP frame, sans the Modbus checksum, as shown in the following diagram. The Modbus checksum is not used, as the standard ethernet TCP/IP link layer checksum methods are instead used to guaranty data integrity.




Note that the Modbus address field is referred to as the *Unit Identifier* in Modbus TCP. In a typical slave application, the Unit ID is ignored and just echoed back in the response.

The operation of the 963/964EN industrial Ethernet modules is very similar to Acromag's 913/914MB ModBus modules. The operation over Ethernet is essentially transparent to the Modbus register/command structure. If you are already familiar with Modbus or with Acromag Series 900MB modules, then you are already familiar with the operation of the 963/964EN modules.

## IP Addressing

A host is any device on any network. On TCP/IP networks, each host has one or more unique IP addresses. This module connected to an ethernet network is a host.

An IP Address is a unique identification number for any host (this module) on any TCP/IP network (including the internet). The IP address is made up of four octets (8 bits), each octet having a value between 0-255 (00H-FFH). The IP address is comprised of two parts: the network address (first part) and the host address (last part). The number of octets of the four total that belong to the network address depend on the Class definition (see below).

## IP Addressing

A *Static IP Address* is as the name implies—static. That is, it is a unique IP Address that is assigned by a service provider and never changes.

A *Dynamic IP Address* is an address that is temporarily assigned to a user by a service provider each time a user connects.

A *Subnet* is a contiguous string of IP addresses. The first IP address in a subnet is used to identify the subnet, while the last IP address in a subnet is always used as a broadcast address. Anything sent to the last IP address of a subnet is sent to every host on the subnet.

Subnets are further broken down into three size classes based on the 4 octets that make up the IP address. A Class A subnet is any subnet that shares the first octet of the IP address. The remaining 3 octets of a Class A subnet will define up to 16,777,214 possible IP addresses ($2^{24} – 2$). A Class B subnet shares the first two octets of an IP address (providing $2^{16} – 2$, or 65534 possible IP addresses). Class C subnets share the first 3 octets of an IP address, giving 254 possible IP addresses. Recall that the first and last IP addresses are always used as a network number and broadcast address respectively, and this is why we subtract 2 from the total possible unique addresses that are defined via the remaining octet(s).

*TIP: the first node (0), node 10, and the last node (255 for our example) are typically reserved for servers and may yield poor results if used.*

For our example, the default IP address of this module is 128.1.1.100. If we assume that this is a Class C network address (based on the default Class C subnet mask of 255.255.255.0), then the first three numbers represent this Class C network at address 128.1.1.0, the last number identifies a unique host/node address on this network (node 100 at address 128.1.1.100).

A *Subnet Mask* is used to determine which subnet an IP address belongs to. The use of a subnet mask allows the network administrator to further divide the host part of this address into two or more subnets. The subnet mask flags the network address, plus the bits of the host portion that are used for identifying the subnetwork. By convention, the bits of the mask for the subnetwork address are all set to 1's (it would also work if the bits were set exactly as in the network address). It's called a mask because it can be used to identify the unique subnet to which an IP address belongs to by performing a bitwise AND operation between the mask itself, and the IP address, with the result being the subnetwork address.

For our Example, if we wish to further divide this network into 14 subnets, then the first 4 bits of the host address will be required to identify the subnetwork (0110), then we would use "11111111.11111111.11111111. 11110000" as our subnet mask. This would effectively subdivide our Class C network into 14 subnetworks of up to 14 possible nodes each.

With respect to the default settings of this module:
Subnet Mask 255.255.255.0 (11111111.11111111.11111111.00000000)
IP Address: 128.1.1.100 (10000000.00000001.00000001.01100100)
Subnet Address: 128.1.1.0 (1000000.00000001.00000001.00000000)

The subnetwork address of 128.1.1.0 has 254 possible unique node addresses (we are using node 100 of 254 possible). Node 0, 10, and 255 addresses are typically reserved for servers and may yield poor results if used.

## Dynamic Host Configuration Protocol (DHCP)

DHCP refers to Dynamic Host Configuration Protocol and is a method used to dynamically assign temporary numeric IP addresses as required. A DHCP server maintains a pool of shared IP addresses which are recycled. When a DHCP device wants to use a TCP/IP application, it must request an IP address from the DHCP server. The DHCP server will check the shared supply, and if all addresses are in use, the server will send a busy signal to the client which tells it to try again later. Static addresses will ensure a connection every time, but dynamic addresses do not.

## Domain Name System (DNS)

DNS refers to the Domain Name System or Domain Name Server and refers to the system used to associate an alphanumeric character string with a numeric IP address. The DNS is actually a distributed database of domain names and corresponding IP addresses. These servers contain information on some segment of the domain name space and make this information available to clients called *resolvers*. For example, the DNS allows us to use "Acromag.com" as an IP address rather than a complicated number string.

## MODBUS REGISTERS

Modbus registers are organized into reference types identified by the leading number of the reference address:

| Reference | Description |
|---|---|
| 0xxxx | Read/Write Discrete Outputs or Coils. A 0x reference address is used to drive output data to a digital output channel. |
| 1xxxx | Read Discrete Inputs. The ON/OFF status of a 1x reference address is controlled by the corresponding digital input channel. |
| 3xxxx | Read Input Registers. A 3x reference register contains a 16-bit number received from an external source—e.g. an analog signal. |
| 4xxxx | Read/Write Output or Holding Registers. A 4x register is used to store 16-bits of numerical data (binary or decimal), or to send the data from the CPU to an output channel. |

*The "x" following the leading character represents a four-digit address location in user data memory.*

*The leading character is generally implied by the function code and omitted from the address specifier for a given function. The leading character also identifies the I/O data type.*

**Note:** The ON/OFF state of discrete inputs and outputs is represented by a 1 or 0 value assigned to an individual bit in a 16-bit data word. This is sixteen 0x or 1x references per data word. With respect to mapping, the LSB of the word maps to the lowest numbered channel of a group and channel numbers increase sequentially as you move towards the MSB. Unused bit positions are set to zero.

All I/O values are accessed via the 16-bit Input or Holding Registers given in the Register Map. Input registers contain read-only information. For example, the current input value read from a channel, or the states of a group of digital inputs. Holding registers contain read/write information that may be configuration data or output data. For example, the high limit value of an alarm operating at an input, or an output value for an output channel.

## Register Functions

Each module has a default factory configuration as noted in the SPECIFICATIONS section. Your application will likely differ from the default configuration and the module will need to be reconfigured. You may reconfigure this module by issuing the appropriate Modbus functions to Register Map registers, as required by your application. You may also use a standard web browser to access the built-in web pages of the module to perform basic operations.

## Register Functions

Below is a subset of standard Modbus functions that are supported by this module along with the reference register addresses that the function operates on. Use these functions to access these registers as outlined in the Register Map for sending and retrieving data.

***IMPORTANT:*** *When using your own software to manipulate the module, please note that the maximum query through the Modbus TCP interface is only 50 registers, due to the maximum buffer size limitations of the TCP/IP stack. As such, you can only request data from 50 registers at one time for commands that access multiple registers. For example, the Read Holding Registers command may only retrieve the contents of registers 40001 to 40051 in one read.*

The following Modbus functions operate on register map registers to monitor, configure, and control module I/O:

| CODE | FUNCTION | REFERENCE |
|---|---|---|
| 01 (01H) | Read Coil (Output) Status | 0xxxx |
| 02 (02H) | Read Input Status | 1xxxx |
| 03 (03H) | Read Holding Registers | 4xxxx |
| 04 (04H) | Read Input Registers | 3xxxx |
| 05 (05H) | Force Single Coil (Output) | 0xxxx |
| 06 (06H) | Preset Single Register | 4xxxx |
| 15 (0FH) | Force Multiple Coils (Outputs) | 0xxxx |
| 16 (10H) | Preset Multiple Registers | 4xxxx |
| 17 (11H) | Report Slave ID (See Below) | *Hidden* |

If an unsupported function code is sent to a module, exception code 01 (Illegal Function) will be returned in the response. If a holding register is written with an invalid value, exception code 03 (Illegal Data Value) will be returned in the response message. You may refer to the Modbus specification for a complete list of possible error codes.

**964EN-4012 Report Slave ID Example Response**

| FIELD | DESCRIPTION |
|---|---|
| Unit ID | Echo Unit ID Sent In Query |
| Function Code | 11 |
| Byte Count | 42 |
| Slave ID (Model No.) | 02=963EN-4012 (12 Current Input)<br>03=964EN-4012 (12 Voltage Input) |
| Run Indicator Status | FFH (ON) |
| Firmware Number String (Additional Data Field) | 41 43 52 4F 4D 41 47 2C 39 33 30 30 2D **31 32 31** 2C 39 **36 34** 45 4E 2D **34 30 31 32** 2C 30 31 32 33 34 35 41 2C 30 31 32 33 34 35 ("ACROMAG,9300-**121**,9**64**EN-**4012**,*serial number&rev*,six-byteMACID") |

For detailed information on Modbus, feel free to download our technical reference "Introduction To Modbus" at www.acromag.com.

## Register Mirroring

For your convenience, 9xxEN Ethernet modules mirror the contents and operation of registers 0xxxx, 1xxxx, & 3xxxx (as applicable) into holding register space (4xxxx) for systems and controllers that cannot directly access registers 0xxxx, 1xxxx, & 3xxxx.

All Modbus registers of this model can now be written to, or read from, using either the standard methods described in the Modbus specification, or through mapping (mirroring) to the Holding Registers. The registers are mapped as follows and specifics follow the mapping:

## Register Mirroring

0xxxx Coil Registers are mapped to 42xxx Holding Registers
1xxxx Input Status Registers are mapped to 41xxx Holding Registers
3xxxx Input Registers are mapped to 43xxx Holding Registers

For 3xxxx Input Registers, the format of the registers are identical and you only need to offset your address by 43000. For example: if you want to read Input Register 1 through the Holding Registers, you would use the "Read Holding Registers" function with an address of 43001.

For the 1xxxx Input Status Registers (where supported), the return data is reformatted to match the Holding Register format. For example: if you request the Input Status for 12 digital inputs, instead of getting 2 bytes returned with the first 12 bits representing the 12 digital inputs, you will get 12 separate words, each set to either 0000H (OFF), or FFFFH (ON).

For the 0xxxx Coil Registers (where supported), reads are handled in the same way as the 1xxxx Input Status Registers. You can also write to the coil registers by using the "Preset Single Register" function with an address offset of 42000. Setting the data to 0000H will turn the coil OFF, while setting the data to FF00H will turn the coil ON. Writing to multiple coils is not supported via register mirroring, you must use the "Write Multiple Coils" function for that.

Note that with respect to Acromag 9xxMB Modbus RTU modules, only 3xxxx Input Registers are mirrored into 4xxxx space, not Coil or Input Status registers as noted here for 9xxEN models.

## Data Types

I/O values for Series 900EN modules are represented by the following simple data types for temperature, percentage, and discrete on/off.

**Summary Of Data Types Used By 900MB/900EN Modules**

| Data Types | Description |
|---|---|
| Count Value | A 16-bit signed integer in range of -32768 to +32767, or unsigned integer in range of 0 to 65535, representing an A/D or DAC count, time value, or frequency. |
| **Percentage (This Model)** | A 16-bit signed integer value in range of -32768 to +32767. ±20000 is used to represent ±100%, yielding a resolution of 0.005%/lsb. For example, -100%, 0% and +100% are represented by decimal values –20000, 0, and 20000, respectively. The full range is –163.84% (-32768 decimal) to +163.835% (+32767 decimal). |
| Temperature | A 16-bit signed integer value with resolution of 0.1°C/lsb. For example, a value of 12059 is equivalent to 1205.9°C, a value of –187 equals –18.7°C. The maximum possible temperature range is –3276.8°C to +3276.7°C. |
| Discrete | A discrete value is generally indicated by a single bit of a 16-bit word. The bit number/position typically corresponds to the discrete channel number for this model. Unless otherwise defined for outputs, a 1 bit means the corresponding output is closed or ON, a 0 bit means the output is open or OFF. For inputs, a value of 1 means the input is ON (Active low near 0V), while a value of 0 specifies the input is OFF or in its high state (usually >> 0V). |

## Register Map
### Model 963EN-4012
### Model 964EN-4012

The following table outlines the register map for Model 963EN-4012 and 964EN-4012 network modules. Modbus functions operate on these registers using the data types noted above (except for Reset Slave & Report Slave ID functions). Unless otherwise noted, Holding Register values are maintained in non-volatile memory.

| Ref | Addr. | Description | Data Type/Format |
|---|---|---|---|
| ***Input Registers (3x References, Read-Only)*** | | | |
| **3**0001 | 0000 | Module Status | Bit 15: 0 (Not Used)<br>Bit 14: Wink Mode Flag<br>1 = Wink Mode (Blinks Run LED for ID)<br>0 = Normal Operation<br>Bit 13: Default Mode Flag<br>1 = Default Mode Indicator<br>0 = Not Default Mode<br>Bits 12-0: 0 (Not Used) |
| **3**0002 | 0001 | Port 0 Input Range (CH0-3) | Bits 15-2: 0 (Not Used)<br>Bits 1,0: **963EN-4012** **964EN-4012**<br>00 0-20mA ±10V<br>01 4-20mA ±5V<br>10 0-11.17mA ±1V<br>11 0-1mA *Reserved* |
| **3**0003 | 0002 | Port 1 Input Range | *Format is same as Port 1 (See Above). Port 1 applies to channels 4-7.* |
| **3**0004 | 0003 | Port 2 Input Range | *Format is same as Port 1 (See Above). Port 2 applies to channels 8-11.* |
| **3**0005 | 0004 | CH00 Status | Bits 15-2: 0 (Not Used)<br>Bits 1,0: Input Signal Status<br>00 In Range<br>01 Over-Range<br>10 Under-Range<br>11 Not Used |
| **3**0006 | 0005 | CH01 Status | *Format is same as CH0 Status.* |
| **3**0007 | 0006 | CH02 Status | *Format is same as CH0 Status.* |
| **3**0008 | 0007 | CH03 Status | *Format is same as CH0 Status.* |
| **3**0009 | 0008 | CH04 Status | *Format is same as CH0 Status.* |
| **3**0010 | 0009 | CH05 Status | *Format is same as CH0 Status.* |
| **3**0011 | 000A | CH06 Status | *Format is same as CH0 Status.* |
| **3**0012 | 000B | CH07 Status | *Format is same as CH0 Status.* |
| **3**0013 | 000C | CH08 Status | *Format is same as CH0 Status.* |
| **3**0014 | 000D | CH09 Status | *Format is same as CH0 Status.* |
| **3**0015 | 000E | CH10 Status | *Format is same as CH0 Status.* |
| **3**0016 | 000F | CH11 Status | *Format is same as CH0 Status.* |
| **30017** | 0010 | CH00 Value | *Percentage: 16-bit signed integer in range of -32768 to +32767, with ±20000 used to represent ±100%. Resolution is 0.005%/lsb. For example, -100%, 0% & +100% are represented by decimal value –20000, 0, & 20000, respectively. Full range is –163.84% (-32768) to +163.835% (+32767).* |

## Register Map
### Model 963EN-4012
### Model 964EN-4012

| Ref | Addr. | Description | Data Type/Format |
|---|---|---|---|
| ***Input Registers (3x References, Read-Only)*** | | | |
| 30018 | 0011 | CH01 Value | *Percentage: See CH0 & Note 1.* |
| 30019 | 0012 | CH02 Value | *Percentage: See CH0 & Note 1.* |
| 30020 | 0013 | CH03 Value | *Percentage: See CH0 & Note 1.* |
| 30021 | 0014 | CH04 Value | *Percentage: See CH0 & Note 1.* |
| 30022 | 0015 | CH05 Value | *Percentage: See CH0 & Note 1.* |
| 30023 | 0016 | CH06 Value | *Percentage: See CH0 & Note 1.* |
| 30024 | 0017 | CH07 Value | *Percentage: See CH0 & Note 1.* |
| 30025 | 0018 | CH08 Value | *Percentage: See CH0 & Note 1.* |
| 30026 | 0019 | CH09 Value | *Percentage: See CH0 & Note 1.* |
| 30027 | 001A | CH10 Value | *Percentage: See CH0 & Note 1.* |
| 30028 | 001B | CH11 Value | *Percentage: See CH0 & Note 1.* |
| 30029 | 001C | CH00 Count | *Raw A/D Count Value (See Note 2)* |
| 30030 | 001D | CH01 Count | *Raw A/D Count Value (See Note 2)* |
| 30031 | 001E | CH02 Count | *Raw A/D Count Value (See Note 2)* |
| 30032 | 001F | CH03 Count | *Raw A/D Count Value (See Note 2)* |
| 30033 | 0020 | CH04 Count | *Raw A/D Count Value (See Note 2)* |
| 30034 | 0021 | CH05 Count | *Raw A/D Count Value (See Note 2)* |
| 30035 | 0022 | CH06 Count | *Raw A/D Count Value (See Note 2)* |
| 30036 | 0023 | CH07 Count | *Raw A/D Count Value (See Note 2)* |
| 30037 | 0024 | CH08 Count | *Raw A/D Count Value (See Note 2)* |
| 30039 | 0025 | CH09 Count | *Raw A/D Count Value (See Note 2)* |
| 30040 | 0026 | CH10 Count | *Raw A/D Count Value (See Note 2)* |
| 30040 | 0027 | CH11 Count | *Raw A/D Count Value (See Note 2)* |
| ***Holding Registers (4x References, Read/Write)*** | | | |
| 40001 | 0000 | Port 0 Input Range (CH0-3) | Bits 15-2: 0 (Not Used)<br>Bits 1,0: **963EN-4012** **964EN-4012**<br>00 0-20mA ±10V<br>01 4-20mA ±5V<br>10 0-11.17mA ±1V<br>11 0-1mA *Reserved* |
| 40002 | 0001 | Port 1 Input Range (CH4-7) | *Format is same as Port 1 (See Above).* |
| 40003 | 0002 | Port 2 Input Range (CH8-11) | *Format is same as Port 1 (See Above).* |
| 40004 | 0003 | Port 0 Scaling Low | *Do Not Use* |
| 40005 | 0004 | Reserved | *Do Not Use* |
| 40006 | 0005 | Port 0 Scaling High | *Do Not Use* |
| 40007 | 0006 | Reserved | *Do Not Use* |
| 40008 | 0007 | Port 1 Scaling Low | *Do Not Use* |
| 40009 | 0008 | Reserved | *Do Not Use* |
| 40010 | 0009 | Port 1 Scaling High | *Do Not Use* |
| 40011 | 000A | Reserved | *Do Not Use* |

***Note:*** *Changes to Holding Registers take effect immediately.*

## Register Map
### Model 963EN-4012
### Model 964EN-4012

| Ref | Addr. | Description | Data Type/Format |
|---|---|---|---|
| ***Holding Registers (4x References, Read/Write)*** | | | |
| **4**0012 | 000B | Port 2 Scaling Low | *Do Not Use* |
| **4**0013 | 000C | *Reserved* | *Do Not Use* |
| **4**0014 | 000D | Port 2 Scaling High | *Do Not Use* |
| **4**0015 | 000E | *Reserved* | *Do Not Use* |
| **4**0016 | 000F | *Reserved* | *Do Not Use* |
| **4**0017 | 0010 | *Reserved* | *Do Not Use* |
| **4**0018 | 0011 | *Reserved* | *Do Not Use* |
| **4**0019 | 0012 | *Reserved* | *Do Not Use* |
| **4**0020 | 0013 | *Reserved* | *Do Not Use* |
| **4**0021 | 0014 | Calibration Access<br><br>And<br><br>Wink Mode Toggle<br><br>And<br><br>Restore Factory Calibration<br><br>And<br><br>**Factory Use Only** | Writing 24106 (5E2AH) here immediately removes write protection from the calibration registers that follow. All other values apply write protection to the calibration registers (except 21845, 44718, and 43981--See Below).<br><br>Writing 21845 (5555H) to this register will cause the module to "Wink" its Run LED. Writing this value a second time will stop "Wink" (Toggles Wink ON/OFF).<br><br>Writing 44718 (AEAEH) will cause the module to restore its factory calibration. This can only be done after "Save Factory Calibration" has been done at the factory.<br><br>Writing 43981 (ABCDH) is reserved for factory use. **This should not be performed by anyone else or operation will be degraded.**<br><br>This register always reads back 0. After a reset, this register is set back to 0 (write protection enabled and no wink).<br><br>**This register is not maintained in flash.** |
| **4**0022 | 0015 | CH0 Cal Hi Range 0 | Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN) |
| **4**0023 | 0016 | CH0 Cal Lo Range 0 | Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN) |
| **4**0024 | 0017 | CH0 Cal Hi Range 1 | Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN) |

## Register Map
### Model 963EN-4012
### Model 964EN-4012

| Ref | Addr. | Description | Data Type/Format |
|---|---|---|---|
| *Holding Registers (4x References, Read/Write)* | | | |
| 40025 | 0018 | *CH0 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40026 | 0019 | *CH0 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40027 | 001A | *CH0 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40028 | 001B | *CH0 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40029 | 001C | *CH0 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40030 | 001D | *CH1 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40031 | 001E | *CH1 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40032 | 001F | *CH1 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40033 | 0020 | *CH1 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40034 | 0021 | *CH1 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40035 | 0022 | *CH1 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40036 | 0023 | *CH1 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40037 | 0024 | *CH1 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40038 | 0025 | *CH2 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40039 | 0026 | *CH2 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40040 | 0027 | *CH2 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40041 | 0028 | *CH2 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40042 | 0029 | *CH2 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40043 | 002A | *CH2 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40044 | 002B | *CH2 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40045 | 002C | *CH2 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40046 | 002D | *CH3 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40047 | 002E | *CH3 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40048 | 002F | *CH3 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40049 | 0030 | *CH3 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |

## Register Map
### Model 963EN-4012
### Model 964EN-4012

| Ref | Addr. | Description | Data Type/Format |
|---|---|---|---|
| *Holding Registers (4x References, Read/Write)* | | | |
| 40050 | 0031 | *CH3 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40051 | 0032 | *CH3 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40052 | 0033 | *CH3 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40053 | 0034 | *CH3 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40054 | 0035 | *CH4 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40055 | 0036 | *CH4 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40056 | 0037 | *CH4 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40057 | 0038 | *CH4 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40058 | 0039 | *CH4 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40059 | 003A | *CH4 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40060 | 003B | *CH4 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40061 | 003C | *CH4 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40062 | 003D | *CH5 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40063 | 003E | *CH5 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40064 | 003F | *CH5 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40065 | 0040 | *CH5 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40066 | 0041 | *CH5 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40067 | 0042 | *CH5 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40068 | 0043 | *CH5 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40069 | 0044 | *CH5 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40070 | 0045 | *CH6 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40071 | 0046 | *CH6 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40072 | 0047 | *CH6 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40073 | 0048 | *CH6 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40074 | 0049 | *CH6 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |

## Register Map
### Model 963EN-4012
### Model 964EN-4012

| Ref | Addr. | Description | Data Type/Format |
|---|---|---|---|
| *Holding Registers (4x References, Read/Write)* | | | |
| 40075 | 004A | *CH6 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40076 | 004B | *CH6 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40077 | 004C | *CH6 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40078 | 004D | *CH7 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40079 | 004E | *CH7 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40080 | 004F | *CH7 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40081 | 0050 | *CH7 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40082 | 0051 | *CH7 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40083 | 0052 | *CH7 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40084 | 0053 | *CH7 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40085 | 0054 | *CH7 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40086 | 0055 | *CH8 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40087 | 0056 | *CH8 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40088 | 0057 | *CH8 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40089 | 0058 | *CH8 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40090 | 0059 | *CH8 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40091 | 005A | *CH8 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40092 | 005B | *CH8 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40093 | 005C | *CH8 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40094 | 005D | *CH9 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40095 | 005E | *CH9 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40096 | 005F | *CH9 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40097 | 0060 | *CH9 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40098 | 0061 | *CH9 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40099 | 0062 | *CH9 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |

## Register Map
### Model 963EN-4012
### Model 964EN-4012

| Ref | Addr. | Description | Data Type/Format |
|---|---|---|---|
| *Holding Registers (4x References, Read/Write)* | | | |
| 40100 | 0063 | *CH9 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40101 | 0064 | *CH9 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40102 | 0065 | *CH10 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40103 | 0066 | *CH10 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40104 | 0067 | *CH10 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40105 | 0068 | *CH10 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40106 | 0069 | *CH10 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40107 | 006A | *CH10 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40108 | 006B | *CH10 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40109 | 006C | *CH10 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40110 | 006D | *CH11 Cal Hi Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40111 | 006E | *CH11 Cal Lo Range 0* | *Raw A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40112 | 006F | *CH11 Cal Hi Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40113 | 0070 | *CH11 Cal Lo Range 1* | *Raw A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40114 | 0071 | *CH11 Cal Hi Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40115 | 0072 | *CH11 Cal Lo Range 2* | *Raw A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40116 | 0073 | *CH11 Cal Hi Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40117 | 0074 | *CH11 Cal Lo Range 3* | *Raw A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| 40118 | 0075 | *Ideal Range 0 Hi* | *Ideal A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40119 | 0076 | *Ideal Range 0 Lo* | *Ideal A/D Count Value (See Note 2). 0-20mA(963EN) or ±10V(964EN)* |
| 40120 | 0077 | *Ideal Range 1 Hi* | *Ideal A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40121 | 0078 | *Ideal Range 1 Lo* | *Ideal A/D Count Value (See Note 2). 4-20mA(963EN) or ±5V(964EN)* |
| 40122 | 0079 | *Ideal Range 2 Hi* | *Ideal A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40123 | 007A | *Ideal Range 2 Lo* | *Ideal A/D Count Value (See Note 2). 0-11.17mA(963EN) or ±1V(964EN)* |
| 40124 | 007B | *Ideal Range 3 Hi* | *Ideal A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |

## Register Map
### Model 963EN-4012
### Model 964EN-4012

| Ref | Addr. | Description | Data Type/Format |
|---|---|---|---|
| ***Holding Registers (4x References, Read/Write)*** | | | |
| **4**0125 | 007C | *Ideal Range 3 Lo* | *Ideal A/D Count Value (See Note 2). 0-1mA(963EN) or Reserved (964EN)* |
| **4**0126 | 007D | *Reserved* | *Reserved – Do Not Use* |
| **4**0127 | 007E | *Reserved* | *Reserved – Do Not Use* |
| **4**0128 | 007F | *Span Cal Register* | *A 16-Bit value whose bit position when set indicates the channel to be calibrated for span. For example: to calibrate span of channel 0, write 0001H to this register. To calibrate span of channel 11, write 0800H to this register.* ***IMPORTANT:*** *You must FIRST write 5E2AH into the Calibration Access Register (Register 40021) before attempting calibration.* |
| **4**0129 | 0080 | *Zero Cal Register* | *A 16-Bit value whose bit position when set indicates the channel to be calibrated for zero. For example: to calibrate zero of channel 0, write 0001H to this register. To calibrate zero of channel 11, write 0800H to this register.* ***IMPORTANT:*** *You must FIRST write 5E2AH into the Calibration Access Register (Register 40021) before attempting calibration.* |
| **4**3001<br>.<br>.<br>. | | *This block Mirrors 3xxxx Registers.* | *Refer to Register Mirroring. 3xxxx Input Registers are mapped to the 43xxx Holding Register space using an address offset of 43000.* |

**Notes (Memory Map):**

1. Input values are 16-bit signed integer values representing percent with a resolution of 0.005%/lsb. ±20000 is used to represent ±100%. The full range is –163.84% (-32768 decimal) to +163.835% (+32767 decimal). For example, -100%, 0% and +100% are represented by decimal values –20000, 0, and +20000, respectively. Bipolar voltage ranges (964EN) use ±100% (span of –20000 to +20000), current ranges (963EN) use 0-100% (span of 0 to 20000).
2. The 964EN A/D Count value is calculated via the expression: count = (32768*Vin*Gain/Vref)+32768, where Vref=1.235V. Gain is 1 (±10V range), 2 (±5V), and 8 (±1.0V).
   The 963EN A/D Count value is calculated via the expression: count = (32768*Iin*49.9Ω*Gain/Vref)+32768, where Vref=1.235V. Gain is 1 (0-20mA & 4-20mA range),
   2 (0-11.17mA range), or 16 (0-1mA range).
3. **WARNING:** Access to calibration registers 40022 through 40129 is not normally required and unintentional writes to these registers should be avoided to prevent module miscalibration.

## SPECIFICATIONS

These DIN-rail mount, industrial ethernet, analog input modules include twelve analog input channels for DC current (963EN), or DC voltage (964EN), and provide an isolated 10/100BaseT Ethernet port for monitoring and control. Units are DC-powered and include reverse polarity protection. Analog inputs (as a group), network, and power are isolated from each other. Input channels share common. Non-volatile reprogrammable memory in the module stores configuration and calibration information.

### Model Numbers

963EN-4012 (Current)
964EN-4012 (Voltage)

The BusWorks model prefix "900" denotes the Series 900 network I/O family. The "EN" suffix denotes EtherNet. Select 963EN for current input, and 964EN for voltage input. The four digit suffix of this model number represents the following options, respectively: "4" = Ethernet; "0" = Default; "12" = 12 Channels.

### Analog Inputs

Twelve analog input channels with a common (RTN) connection for DC current or DC voltage applications only. AC current inputs can be accommodated when the 963EN is used with an optional AC current sensor (Acromag Model 5020-350). Units must be wired and configured for the intended input type and range (see Connections Section for details). The unit can accept one of several input ranges as described below.

**DC Current (963EN Only):** Configurable for 0 to 20mA, 4-20mA, 0-11.17mA, and 0-1mA DC nominal input ranges. A precision 49.9Ω current sink resistor converts the input current to a voltage that is processed by the A/D converter. An optional external sensor is required to monitor AC current signals (Acromag Model 5020-350). This sensor generates a DC milliampere signal of 0 to 11.17mA for the module (see Table 1 below for scaling to AC current).

**Current Input Reference Test Conditions:** 4 to 20mA current input; Ambient Temperature = 25°C.

**Input Overvoltage Protection:** Bipolar Transient Voltage Suppressers (TVS), 5.6V clamp level typical.

**Optional AC Current Sensor (Model 5020-350, For Use With 963EN):** This sensor is a toroidal instrument transformer that converts a sinusoidal 50-60Hz AC current signal into a low level DC milliampere signal of 0 to 11.17mA. The input AC current range is a function of the number of turns placed through the toroid as shown in Table 1 below. This sensor is isolated and requires no calibration or adjustment. When used with a 963EN module, it provides redundant input isolation and may facilitate input-to-input isolation of this twelve channel unit.

**Table 1: Optional AC Current Sensor Turns & Range**

| AC Current Input Range | Primary Turns | Sensor Output (Red/Black Wires) |
|---|---|---|
| 0 to 20A AC | 1 | 0 to 11.17mA DC |
| 0 to 10A AC | 2 | " |
| 0 to 5A AC | 4 | " |
| 0 to 2A AC | 10 | " |
| 0 to 1A AC | 20 | " |

The output wires of this sensor are polarized with red as (+) plus and black as (-) minus. Normally these output wires are attached to one end of a user supplied cable, while the other end connects to the 963EN's process current input terminals.

## Analog Inputs

**Input Burden**: A function of the wire gauge resistance used for primary turns (the current carrying wire being monitored).
**AC Current Sensor to Transmitter Wiring Distance**: 400 feet maximum for 18 gauge wire. Other wire gauges can be used as long as the resistance of both wires is less than 5Ω.
**Input Overload**: The AC current sensor will withstand overload conditions as follows:

- 20 times full scale for 0.01 seconds.
- 10 times full scale for 0.1 seconds.
- 5 times full scale for 1.0 second.

**DC Voltage (964EN Only):** A 10:1 input divider is installed at the input (using divider resistor values of 100K and 10.5K). Configurable for bipolar DC voltage ranges of -1V to 1V, -5V to 5V, and -10V to 10V.
**Input Impedance:** 110.5KΩ.
**Voltage Input Reference Test Conditions:** -10 to 10V DC Input; Ambient Temperature = 25°C.
**Input Overvoltage Protection:** Bipolar Transient Voltage Suppressers (TVS), 18V clamp level typical.

**Note:** Channels of the same port (each group of 4 channels) must share the same range configuration, but the range configuration may vary port-to-port.

## General Specifications

**Accuracy:** Accuracy is better than ±0.05% of span, typical, for nominal input ranges. This includes the effects of repeatability, terminal point conformity, and linearization, but does not include sensor error.
**Measurement Temperature Drift:** Better than ±50ppm/°C (±0.005%/°C).
**Analog to Digital Converter (A/D):** 16-bit Σ-Δ converter.
**Resolution:** 0.005% or 1 part in 20000 (963EN), 0.0025% or 1 part in 40000 (964EN, full bipolar range).
**Input Conversion Rate:** 180ms per channel, or 2.16s for twelve channels.
**Input Filter:** Normal mode filtering, plus digital filtering, optimized and fixed per input range within the Σ-Δ ADC.
**Input Filter Bandwidth:** -3dB at 3Hz, typical.
**Noise Rejection (Normal Mode):** 40dB @ 60Hz, typical with 100Ω input unbalance.
**Noise Rejection (Common Mode):** 140dB @ 60Hz, typical with 100Ω input unbalance.
**Data Type:** Percent. 16-bit signed integer value with resolution 0.005%/lsb. ±20000 is used to represent ±100%. For example, -100%, 0% and +100% are represented by decimal values –20000, 0, and 20000, respectively. Full range is –163.84% (-32768) to +163.835% (+32767).

## Enclosure & Physical

**Dimensions:** 1.05 inches wide, 4.68 inches tall, 4.35 inches deep. Refer to the dimensions drawing at the front of this manual.
**DIN Rail Mount:** Type EN50022; "T" rail (35mm).
**I/O Connectors:** Removable plug-in type terminal blocks rated for 15A/300V; AWG #12-24 stranded or solid copper wire.
**Network Connector:** 8-pin RJ-45 connector socket with metal shield (shield is bypassed to earth ground at the GND terminal via an isolation capacitor and TVS). Connections are wired MDI, as opposed to MDI-X. You must use a CAT-5 crossover cable to connect this module to a PC. Otherwise you may use an auto-crossing Ethernet switch, such as the Acromag 900EN-S005 to make connections.

## Enclosure & Physical

| RJ-45 | Signal (MDI) | Description |
|---|---|---|
| 1 | Tx+ | Transmit Positive |
| 2 | Tx- | Transmit Negative |
| 3 | Rx+ | Receive Positive |
| 4 | Not Used | Connects to Pin 5 |
| 5 | Not Used | Connects to Pin 4 |
| 6 | Rx- | Receive Negative |
| 7 | Not Used | Connects to Pin 8 |
| 8 | Not Used | Connects to Pin 7 |

**Case Material:** Self-extinguishing NYLON type 6.6 polyamide thermoplastic UL94 V-2, color beige; general purpose NEMA Type 1 enclosure.
**Printed Circuit Boards:** Military grade FR-4 epoxy glass.
**Shipping Weight:** 1 pound (0.45 Kg) packed.

## Agency Approvals

**Safety Approvals:** CE marked (EMC Directive 89/336/EEC), UL Listed (UL3121-First Edition, UL1604), cUL Listed (Canada Standard C22.2, No. 1010.1-92), Hazardous Locations: Class 1; Division 2; Groups A, B, C, & D.

## Environmental

**Operating Temperature:** -25°C to +70°C (-13°F to +158°F).
**Storage Temperature:** -40°C to +85°C (-40°F to +185°F).
**Relative Humidity:** 5 to 95%, non-condensing.
**Power Requirements:** Non-polarized 15-36V DC SELV (Safety Extra Low Voltage). Observe proper polarity. See table for current.

***CAUTION:*** *Do not exceed 36VDC peak, to avoid damage to the module.*

***External Fuse:*** *Select a high surge tolerant fuse rated for 1A or less to protect unit.*

| Supply | 963EN-4012 Current | 964EN-4012 Current |
|---|---|---|
| 15V | 102mA Typ/112mA Max | 103mA Typ/113mA Max |
| 18V | 85mA Typ/94mA Max | 87mA Typ/96mA Max |
| 24V | 66mA Typ/73mA Max | 67mA Typ/74mA Max |
| 36V | 49mA Typ/54mA Max | 49mA Typ/54mA Max |

**CAUTION:** Risk of Electric Shock – More than one disconnect switch may be required to de-energize equipment before servicing.

*Note that input channels are not isolated channel-to-channel.*

**Isolation:** Input channels (as a group), power, and network circuits are isolated from each other for common-mode voltages up to 250VAC, or 354V DC off DC power ground, on a continuous basis (will withstand 1500VAC dielectric strength test for one minute without breakdown). Complies with test requirements of ANSI/ISA-82.01-1988 for voltage rating specified.
**Installation Category:** Designed to operate in an installation in a Pollution Degree 2 environment with an installation category (over-voltage category) II rating.
**Electromagnetic Interference Immunity (EMI):** Measurement shift is less than ±0.25% of input span for interference from switching solenoids, commutator motors, and drill motors.

## Environmental

*These limits represent the minimum requirements of the standard, but product has typically been tested to comply with higher standards in some cases.*

**Electromagnetic Compatibility (EMC) -**

**Minimum Immunity Per European Norm EN50082-1:**

**Electrostatic Discharge (ESD) Immunity:** 4KV direct contact and 8KV air-discharge to the enclosure port per EN61000-4-2.

**Radiated Field Immunity (RFI):** 10V/M, 80 to 1000MHz AM and 900MHz keyed carrier, per EN61000-4-3 and ENV50204.

**Electrical Fast Transient Immunity (EFT):** 2KV to power, and 1KV to signal I/O per EN61000-4-4.

**Conducted RF Immunity (CRFI):** 10V rms, 150KHz to 80MHz, per EN61000-4-6.

**Surge Immunity:** 0.5KV per EN61000-4-5.

**Emissions Per European Norm EN50081-1:**

**Radiated Frequency Emissions:** 30 to 1000MHz per EN55022 Class A

**WARNING:** This is a Class A product. In a domestic environment, this product may cause radio interference in which the user may be required to take adequate measures.

**IMPORTANT:** Power, input, and output (I/O) wiring must be in accordance with Class I, Division 2 wiring methods of Article 501-4(b) of the National Electrical Code, NFPA 70 for installations in the US, or as specified in section 18-1J2 of the Canadian Electrical Code for installations within Canada and in accordance with the authority having jurisdiction.

**This equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D, or non-hazardous locations only.**

**WARNING – EXPLOSION HAZARD –** Substitution of components may impair suitability for Class I, Division 2.

**WARNING – EXPLOSION HAZARD –** Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

## Ethernet Interface

**Connector:** Shielded RJ-45 socket, 8-pin, 10BaseT/100BaseTX.

**Wiring:** Wired MDI. Unit does NOT support auto-crossover. Use a crossover cable to connect your PC to this module.

**Protocol:** Modbus TCP/IP with optional web-browser configuration.

**IP Address:** Default static IP address is 128.1.1.100.

**Port:** Up to 10 sockets supported. Uses port number 502 which is reserved for Modbus.

**Transient Protection:** Transient Voltage Suppressors are applied differentially at both the transmit and receive channels. The metal shield of the RJ45 socket is capacitively coupled to the earth ground terminal via an isolation capacitor and TVS.

**Data Rate:** Auto-sensed, 10Mbps or 100Mbps.

**Duplex:** Auto-negotiated, Full or Half Duplex.

**Compliance:** IEEE 802.3, 802.3u, 802.3x.

**Modbus TCP/IP Protocol Support:** Uses built-in web pages for configuration and control over ethernet via a standard web browser. Up to 10 sockets may be selected. The module uses the standard Modbus TCP/IP port number 502.

**Rx/Tx Memory:** 8K bytes internal SRAM memory for receive and transmit buffers (FIFO).

## Ethernet Interface

*Refer to Acromag Application Note 8500-734 for instructions on how to change the IP address of your PC network interface card in order to talk to an Acromag module.*

**Communication Distance:** The distance between two devices on an Ethernet network is generally limited to 100 meters using recommended copper cable. Distances may be extended using hubs, switches, or fiber optic transmission. However, the total round trip delay time must not exceed 512 bit times for collision detection to work properly.

**Port Status Indicators:** Green LED indicates link status (ON if auto-negotiation has successfully established a connection), yellow LED indicates activity (ethernet connection is busy/traffic is present).

**Address:** The module IP address can be preset by the user (static) and loaded from internal non-volatile memory, or it can be automatically acquired at startup via the network server using a BOOTP (Bootstrap Protocol), or DHCP (Dynamic Host Configuration Protocol). The unit also includes a default mode toggle switch to cause the module to assume a "known" fixed static IP address of 128.1.1.100 for troubleshooting purposes.

## Controls & Indicators

**LED Indicators:**

**RUN (Green) -** Constant ON if power is on and unit is OK. Continuous flashing ON/OFF indicates unit is in "wink" ID mode.

**ST (Yellow) –** Slowly blinks ON/OFF in default mode, constant ON if one or more inputs are over/under-range.

**LINK (Green) –** Indicates Ethernet link status (ON if auto-negotiation has successfully established a connection).

**ACT (Yellow)** – Blinking indicates Ethernet activity (Ethernet connection is busy/traffic is present).

**Controls:**

**Reset/Default Address Switch:** This momentary toggle switch is located on the front panel and is used to either reset the module (toggle right), or toggle the module into, or out of Default Communication Mode (toggle left). In Default Mode, the module assumes the fixed static IP address "128.1.1.100", a default subnet mask "255.255.255.0", a default username of "User", and a default password of "password00". This switch can also be used to restore the module to its initial factory configuration by holding this switch in its default position while powering up the unit (see "Getting Out Of Trouble" in the Troubleshooting section for more information).

## ACCESSORY CABLES

The minimum cable required for full operation of this device is Category 5. The term "Category" refers to classifications of UTP (Unshielded Twisted Pair) cables. There are 3 main categories of cable – Category 3, Category 4, and Category 5. The differences in classification is found in their electrical performance and this is documented in the TIA/EIA 568A standard. Category 5 cable includes four twisted wire pairs at eight twists per foot.

This device is designed for use in harsh industrial environments. Acromag recommends the use of shielded cable when wiring to this device. Select STP (Shielded Twisted Pair) cable rather than UTP (Unshielded Twisted Pair). The use of shielded cable will help protect the data being transmitted from harmful EMI (Electromagnetic Interference) and RFI (Radio Frequency Interference). It will also help to lower your radiated emissions by keeping the cable from emitting EMI and RFI.

There are two types of cable conductors: solid cable and stranded cable. Stranded cables are more flexible than solid cables. But since attenuation is higher for stranded cables than solid conductor cables, these are generally reserved for short runs and patch applications less than 6 meters.

Currently there are two types of cable shielding employed in Category 5 STP cable: single-shielded cable and double-shielded cable. Both of these cables have the same core and jacket as UTP cables, but also include a thin foil outer shield that covers all four twisted-wire pairs. Some variations will also include a drain wire that encircles the outer foil. The double-shielded version adds an outer wire screen that wraps around the foil shield and also functions as a drain wire. The drain wire or wire screen typically makes contact at each end of the cable with the metal shield around special RJ45 plug connectors. The metal shield of these connectors then makes contact with the metal shield of shielded RJ45 sockets. The socket shield may make direct contact with earth ground, or it may be capacitively coupled to earth ground.

In the Acromag 9xxEN modules, this shield contacts earth ground via a high voltage capacitor and transient voltage suppressor. In addition to minimizing radio frequency and electromagnetic interference, this arrangement also has the added benefit of enhanced protection from damage due to ESD (Electro-Static Discharge).

Further, Acromag recommends the use of *enhanced* Category 5 cable (CAT-5e). This cable has all the characteristics of Category 5, but includes enhancements that help to minimize crosstalk. It is rated for frequencies up to 200MHz, double the rate of Category 5. Category 5e cable also has a greater number of turns-per-inch in its twisted pairs, making its performance more suitable for applications that make use of all four wire pairs for simultaneous bidirectional data transmission (full-duplex). This cable is defined in TIA/EIA-568A-5 (Addendum 5).

## Patch Cable & Crossover Cable

Acromag offers the following cable accessories for use with this module:

**Cable Model 5035-355** – Yellow, 3 foot long, single-shielded Category 5e STP patch cable with drain wire and an RJ45 plug at both ends. Use this cable to connect any Acromag 9xxEN I/O module to the 900EN-S005 switch.
**Cable Model 5035-360** – Green, 5 foot long, single-shielded Category 5e STP crossover cable with drain wire and an RJ45 plug at both ends. This cable performs the Ethernet crossover function and is used to connect a PC directly to an Acromag Series 9xxEN I/O module.

Note that you do not need to use a crossover cable to connect your PC to this module if the Acromag 900EN-S005 switch is used between the PC and module, as the switch is auto-crossing. However, you must use a crossover cable when directly connecting your PC to a Series 9xxEN I/O Module without the use of an auto-crossing switch or hub.

You may obtain cable in other lengths and colors as required for your application from other vendors. For example, shielded CAT-5e cable is available from the following vendors:

- L-com Connectivity Products, www.L-com.com
- Pro-Link, www.prolink-cables.com

For very noisy environments or in the presence of strong electrical fields, you can obtain double-shielded CAT-5e cable and shielded RJ45 plugs from the following vendors:

- L-com Connectivity Products, www.L-com.com, see cable model TFSC2004 and shielded plug T8P8CSR.
- Regal Electronics, www.regalusa.com, see shielded plug model 1003B-8P8CSR-C5.

Complete premium double-shielded Category 5e standard and crossover cables in variable lengths can be obtained from Lumberg at www.lumbergusa.com (refer to their etherMate line). For example, specify RJ45S-RJ45S-656/B/3M for a double-shielded, 3 meter straight cable. Specify RJ45S-RJ45S-656/BX/3M for a double-shielded, 3 meter crossover cable.